European Fitness Badge (EFB) – Development, Implementation and Evaluation of a Europe-wide Fitness Test

Zur Erlangung des akademischen Grades einer

DOKTORIN DER PHILOSOPHIE (Dr. phil.)

von der KIT-Fakultät für Geistes- und Sozialwissenschaften des

Karlsruher Instituts für Technologie (KIT)

angenommene

DISSERTATION

von

Katja Klemm

KIT-Dekan: Prof. Dr. Michael Schefczyk

1. Gutachter: Prof. Dr. Klaus Bös

2. Gutachter: Prof. Dr. Walter Brehm

Tag der mündlichen Prüfung: 20.01.2021

Acknowledgments

Diese Dissertation wurde im Rahmen des EU Erasmus+ Projekts „European Fitness Badge“ angefertigt und dient als zusammenfassende Evaluation des Projekts. Zuallererst möchte ich somit allen internationalen und nationalen Projektpartnern für die spannende und lehrreiche Zeit während der beiden Projektphasen von 2015 bis 2019 danken. Es heißt immer, ein internationales Projekt sei ganz gut, aber die Zusammenarbeit und das gemeinsame Entwickeln eines Produkts, an das alle gleichermaßen glauben und ihr Wissen miteingebracht haben, war eine Erfahrung, die ich nie vergesse und in keinem Fall missen möchte. Besonders hervorheben möchte ich folgende Personen, mit denen wir besonders viel Zeit, Herzblut und auch Schweiß in das EFB gesteckt haben: Pia Pauly, Miriam Schreck und Maria-Lourdes Gonzales (Luli) vom Deutschen Turner-Bund; Michael Butzke von mb-mediasports; Ine De Clerck und Bart von Houtte von der Artevelde University of Applied Sciences in Belgien; Linn Trentel Busch und Anders Kragh Jespersen von DGI in Dänemark; Toni Llop von UBAE in Spanien. Insgesamt vielen Dank für die großartigen Meetings, die bereichernden Diskussionen und den europaweiten Austausch, auch an die Partner aus Slowenien, Österreich und Bulgarien!

Zu diesem Projekt inkl. meiner Masterarbeit, Dissertation und dem Kennenlernen von so vielen tollen Personen wäre ich aber besonders ohne einen Menschen nicht gekommen: Prof. Dr. Klaus Bös. Bei ihm möchte ich mich zuallererst für diese Möglichkeit bedanken und dann für die sehr gute Betreuung während meiner Master- sowie meiner Doktorarbeit, den zahlreichen Tipps (ob fachspezifisch oder nicht), der immerwährenden Unterstützung und der angemessenen Kritik sowie der hilfreichen Motivation in den richtigen Momenten. Ohne ihn würde ich diese Danksagung sicherlich nicht schreiben, also vielen herzlichen Dank für alles, lieber Klaus!

Wohl genauso hilfreiche Kritik und Motivation habe ich auch von meinem Zweitgutachter und Projektmitstreiter Prof. Dr. Walter Brehm erhalten. Durch ihn habe ich viele Impulse erhalten, die meine Arbeit für und während der Dissertation sehr bereichert hat. Ich freue mich sehr, dass er hier seine wertvolle Zeit miteingebracht hat. Vielen lieben Dank, lieber Walter!

Eine solche Dissertation lebt auch von der Unterstützung und dem Austausch am ansässigen Institut. Hier möchte ich mich bei Prof. Dr. Alexander Woll bedanken, in dessen Arbeitsgruppe ich mich sehr wohl und gut aufgenommen gefühlt habe. Besonders hilfreich waren die zahlreichen Treffen im Doktorandenkolloquium, in denen wertvolle Tipps und Rückmeldung aus dem Kreis der Doktoranden und auch aus dem Kreis der Post-Docs und Professoren kamen. Das EFB war stets ein kleines Projekt, sodass ich die Gespräche und die Vernetzung mit anderen Projekten stets als sehr fruchtbar empfand. Vielen Dank an alle hierfür! Die Arbeit am IfSS lebte aber auch von der Zusammenarbeit und dem Austausch mit einer Vielzahl an weiteren Personen, bei denen ich mich ausdrücklich bedanken möchte: Petra Glaser, die immer ein offenes Ohr für mich hat und jederzeit mit Rat und Tat zur Seite steht; Sina

Hartmann, für die seelische Unterstützung in allen Belangen, für das Korrekturlesen, die so hilfreichen Kaffee- / Teepausen sowie die tolle Freundschaft; Rita Wittelsberger, für die gute Zusammenarbeit im Hector-Projekt und beim Deutschen Walking Institut; Dr. Steffen Schmidt und Dr. Janina Krell-Rösch, für die wertvolle Zusammenarbeit, besonders bei den entsprechenden Veröffentlichungen; Anika Gunst für die schöne gemeinsame Arbeit zu Beginn des Projekts EFB und die tolle Freundschaft; die studentischen Hilfskräfte Vincent Grady, David Ehrler, Melissa Böckle, Carla Schlembach, Mirija Marschall, Annika Mörike, Lea Siebenhaar, Louisa Schneider, Larissa Heißler, Lisa Lorenz; allen EFB Testhelfer und -helferinnen; allen Kolleginnen aus der Kinderklinik; sowie allen aktuellen und ehemaligen Kolleginnen und Kollegen am IfSS. Vielen Dank!

Einen sehr großen Dank möchte ich zudem meiner Familie aussprechen, ohne die ich diese Dissertation sicherlich nicht geschafft hätte. Mit ihrer emotionalen und auch fachlichen Unterstützung haben mir meine Eltern immer zur Seite gestanden und mich stets weitergebracht. Ihr habt mir das Beste von euch mitgegeben und damit habe ich auch diese Arbeit euch zu verdanken. Lieben Dank für alles, liebe Lieblingseltern! Meinem Lieblingsbruder Kay möchte ich für die ein oder anderen ablenkenden Besuche danken und ebenso für die stetige Unterstützung. Für die emotionale und auch finanzielle Unterstützung möchte ich mich bei meiner Oma Eichen und meiner Tante Irmi bedanken, ohne sie wäre ich wohl auch nie so weit gekommen. Meiner Oma Mambach, die leider die Abgabe dieser Arbeit nicht mehr miterlebt, möchte ich für ihre lebenslange Unterstützung und Liebe danken. Diese Arbeit ist auch für dich, Oma. Meiner gesamten Familie und Schwieger-Familie möchte ich dafür danken, dass sie immer für mich da ist und ich kann mich glücklich schätzen, euch zu haben.

Immer an meiner Seite und immer als mein Fels in der Brandung möchte ich Yannick danken. Egal ob es gut lief oder eben auch mal nicht, falls die Technik oder ich mal nicht mehr wollte oder ich einfach mal etwas anderes als Sportwissenschaft hören und sehen musste, auf dich kann und konnte ich mich während der Promotionszeit und darüber hinaus stets verlassen. Dafür möchte ich dir von Herzen vielmals danken!

Feiern möchte ich diese Dissertation aber auch mit meinen Freunden. Allen voran bedanke ich mich bei Jenny für ihre inzwischen jahrzehntelange Freundschaft und besonders für die regelmäßigen motivierenden oder auch ablenkenden Telefonate in den letzten Jahren. Ich bin sehr froh, dass es dich und unsere Freundschaft gibt! Zudem möchte ich mich bei Julia, Franzi, Merle, Natascha, Charlotte, Alex, Elena und Melli für ihre Freundschaft und Unterstützung in den letzten Jahren bedanken. Ich freue mich auf die kommenden Jahre!

Zum Schluss möchte ich das Zitat aus meiner Masterarbeit wiederholen:

„Anytime you see a turtle up on top of a fence post, you know he had some help.“

*(Alex Haley, amerikanischer Autor, *1921†1992)*

Und damit VIELEN DANK an alle für die Hilfe und Unterstützung!

Structure

Preface

"The project has as its overall objective to increase citizen participation in sport and physical activity across Europe via an innovative and motivating "European Fitness Badge"." This is the first sentence of the European Union (EU) Erasmus+ application written in 2014. For me the start was in 2015, when Prof. Dr Klaus Bös called for student workers for a European project in our master lecture. At that time, I was particularly motivated by the idea of a European fitness test. The aim was to develop a new instrument for displaying health-oriented fitness with an international team of scientists and practitioners. These partners out of various organizations and with at least as many different sports systems in their country, had the idea of a collaborative partnership to motivate people to physical activity.

The initial situation was clear for everyone; the inactivity crisis with a high level of inactivity and still rising numbers of inactive people was present (and still is five years later) all over Europe. Increasing numbers of overweight, non-communicable diseases as diabetes type II and cardiovascular diseases accompany this crisis.

Nevertheless, the initial idea of a fitness test was also clear for all partners. With this idea in our minds, the partnership developed the European Fitness Badge (EFB) for European adults from 2015 to 2017. Ideas changed, new aspects arose out of several meetings and my position changed from student worker to PhD student. I learned a lot, on personal and professional level, with the EFB growing from an idea to a scientifically based and proven fitness test in Europe.

After publication during a big international event in Berlin in 2017, the second funding phase started in 2018 with the aim of dissemination and improvement. For this purpose, the partnership was adjusted in some parts and special partners for dissemination joined the project. In December 2019, the project ended up with over 6,000 participants in eight countries and the remaining idea of the test continuing to live through the partnership all-over Europe and through the partners in their countries.

This thesis is an ending point and a starting point at the same time. With evaluating the project, a summary of it is executed from developing the concept in 2015 to the dissemination in 2019. This is the ending point. The starting point is the upcoming future of the EFB with more partner countries joining the collaboration, more participants executing the EFB and more research related to the EFB.

This cumulative thesis is based on the following manuscripts, published or under review in peer-reviewed journals:

Manuscript 1:

Klemm, K., Brehm, W., Bös, K. (2017). The European Fitness Badge as a diagnostic instrument for the HEPA concept – development and evaluation. Leipziger Sportwissenschaftliche Beiträge, 58(2), S. 83-105.

Manuscript 2:

Klemm, K., Krell-Roesch, J., De Clerck, I.L., Brehm, W. and Boes, K. (2021). Health-Related Fitness in Adults From Eight European Countries—An Analysis Based on Data From the European Fitness Badge. Front. Physiol. 11:615237. doi: 10.3389/fphys.2020.615237

Manuscript 3:

Klemm, K., Brehm, W., Schmidt, S., De Clerck, I. L., & Bös, K. (2020). Fit and Healthy in Middle Adulthood – Do Fitness Levels Make a Difference. Central European Journal of Sport Sciences and Medicine, 30, 33–46. https://doi.org/10.18276/cej.2020.2-04

Abstract

The European Fitness Badge (EFB) was developed by an international project group during two funding phases (1: 2015 - 2017, 2: 2018 - 2019) of the EU Erasmus+ programme. It is an online-based tool to assess the health-related fitness of persons aged ≥ 18 years residing in European countries. Two different test batteries (test profiles, TP) are available to distinguish between less active (TP1) and active individuals (TP2). Those test batteries include eleven validated motor tests to measure endurance, strength, coordination and flexibility performance. The EFB additionally assesses body composition (as indicated by body mass index, BMI), body stability, posture abnormalities and engagement in physical activity. After performing the EFB with an EFB instructor, participants got an individual feedback and counselling based on their EFB fitness results.

The main aim of this thesis is to present the European health-related fitness status according to the evaluation of the EFB. The following research questions build this aim:

(1) How do instructors, participants and experts rate the EFB concept (overall structure, test profiles and items)?

(2) Who participated at the EFB?

(3) Does the health-related fitness status, displayed by the EFB results, relate to participants health?

(1) How do instructors, participants and experts rate the EFB concept (overall structure, test profiles and items)?

The project "European Fitness Badge (EFB) – a way of health promoting physical activity" is led by the German Gymnastic Federation (Deutscher Turner-Bund). The federation established the badge with an international partnership during the first project period ending July 1st, 2017. Two test profiles with corresponding three levels for awarding the fitness status were developed. The HEPA concept served as an orientation for the evaluation of the test results as well as the following counselling.

For proving the acceptance, feasibility and psychometric properties of both test profiles a study was conducted between March and April 2016. 86 participants (TP1: N = 22, age = 24 - 76 years; TP2: N = 64, age = 26 - 67 years) executed the EFB with the help of six test instructors. Participants performed the EFB twice with one week in between. During the retest in the second test week, 19 participants at TP1 and 60 participants at TP2 took part. Regarding the validity, all test items have been verified through a test expert rating (N = 16).

The results of evaluations show positive tendencies in aspects of psychometric properties (objectivity and reliability: 67 - 100% accordance in TP1 and r = 0.70 - 0.93 in TP2), acceptance (5-tier-scale: M =

1.5 (SD = 1.4) at TP1 and M = 1.5 (SD = 1.2) at TP2) and feasibility (5-tier-scale: M = 1.5 (SD = 1.8) at TP1 and M = 1.4 (SD = 0.6) at TP2) by participants, instructors and experts. These results need to be handled carefully due to the small sample and the wide age range.

(2) Who participated at the EFB?

There are conflicting reports about the fitness status of European adults, partly due to the lack of a standardized fitness test battery used across Europe. The European Fitness Badge (EFB) was developed in 2017 as an online-based tool to assess the health-related fitness of persons aged ≥ 18 years residing in European countries. We examined the demographic characteristics and fitness status of persons who completed the EFB between June 2017 and May 2019.

We conducted a multinational study in eight European countries. Participants completed the EFB which includes eleven validated motor tests to measure endurance, strength, coordination and flexibility performance, under the supervision of an EFB instructor in different settings (e.g. sports club sessions, public events). Two different test batteries (test profiles, TP) are available to distinguish between less active (TP1) and active individuals (TP2). We calculated descriptive statistics and conducted analyses of variance to examine sample characteristics and a potential impact of sex, age, body mass index (BMI), physical activity and posture on fitness as assessed by the EFB.

The sample included 6,019 adults (68.7% females; mean age 52.7 years; age range 18-89 years). Participants who completed TP1 were older (TP1: 61.4 years; TP2: 44.2 years; p = 0.00), reported a lower level of physical activity (TP1: 3.8; TP2: 4.0; p = 0.00), had a higher BMI (TP1: 25.7; TP2: 24.3; p = 0.00) and a higher frequency of postural abnormalities (TP1: 43%; TP2: 33%; p = 0.00) than TP2 participants. Among 3,034 participants who completed TP2, males had higher performance in endurance, strength and overall fitness, whereas females performed better in coordination and flexibility tests. In addition, younger age, lower BMI and higher level of physical activity engagement was associated with better EFB test performance.

The EFB can be used to assess the health-related fitness status of individuals aged ≥ 18 years. Our results show that TP1 and TP2 were completed by persons from the respective target groups (i.e. less active vs. active), and also confirm findings from previous studies on potential determinants of fitness such as sex or age.

(3) Does the health-related fitness status, displayed by the EFB results, relate to participants health?

Strong evidence exists, that fitness is a physical health resource, which serves to protect one´s health. There is still uncertainty about which fitness level provides the best health outcome and which measurements is useful for analysing this question. The cross-sectional study analysed 462 (64.07% female) German middle-aged adults regarding their fitness status, physical activity (Non-Exercise test),

body composition (Body Mass Index) and heart-related health status. Motor tests were used to measure the health-related fitness status. The heart-related health status was surveyed by questionnaire and diagnosis was done in part by a physician. Relationships between risk factors and fitness factors are visible during the correlative analysis (correlations between 0.17 to 0.46). They are substantially more visible in the differentiation of people with and without risks. People with low fitness show noticeable risks in activity (men = 36 - 58%, women = 38 - 43%), Body Mass Index (men = 19 - 26%, women = 10 - 22%) and heart-related health (men = 19 - 26%, women = 10 - 22%). People with high fitness show health resources for activity, Body Mass Index and heart-related health. This study points out that all fitness dimensions influence one´s heart-related health in a positive way. Fitness is measured objectively and includes all health-related fitness dimensions such as endurance, strength, coordination and flexibility.

In conclusion, the EFB is an international instrument to present the health-related fitness of Europeans under specified restrictions. At this time, the EFB is the only multinational health-related fitness test for adults used in Europe. Concept, scientific character, purpose and target group are proven and considered as good or accordable improvements were made. After two years of real field tests, participant's data were analysed regarding the health-related fitness status. This needs to be continued. With further promotion and national and international dissemination strategies, limitations as the different participant numbers per country can be reduced. Strategies and concepts for special target groups and relevant target groups as inactive people need to be put in practice.

According to the World Health Organization, a common international interest is to stay or get healthy. This interest only will be reached in including all health-related areas. The interaction between sport, physical activity and fitness is one aspect of this complex construct. If the EFB contributes to the complex construct in moving people or motivate them to stay active, the aim of the EFB and its developers is reached.

Zusammenfassung

Das Europäische Fitness Abzeichen (European Fitness Badge, EFB) wurde von einer internationalen Projektgruppe während zwei Förderphasen innerhalb des EU Erasmus+ Programms (1: 2015 - 2017, 2: 2018 - 2019) entwickelt. Das EFB ist ein online-basiertes Instrument zur Messung der gesundheitsorientierten Fitness erwachsener Europäer. Zwei verschiedene Testbatterien (Testprofile, TP) machen es möglich, zwischen wenig aktiven (TP1) und aktiven Personen (TP2) zu differenzieren. Die beiden Testbatterien beinhalten elf validierte motorische Testaufgaben um Ausdauer, Kraft, Koordination und Beweglichkeit zu testen. Zusätzlich erhebt das EFB Daten zur Körperkonstitution (gemessen über den Body Mass Index, BMI), Körperstabilität, Körperhaltung und der körperlichen Aktivität. Nach der Durchführung des EFB mit einem ausgebildeten Testleitenden erhalten die Teilnehmenden aufbauend auf ihren Ergebnissen ein individuelles Feedback und eine Beratung.

Das Hauptziel dieser Dissertation ist die Darstellung des europäischen gesundheitsorientierten Fitnessstatus anhand der Evaluation des EFB. Die folgenden Forschungsfragen lassen sich von diesem Ziel ableiten:

(1) Wie bewerten Testleitende, Teilnehmende sowie Experten und Expertinnen das EFB Konzept (Gesamt, Testprofile, Testaufgaben)?
(2) Wer nahm am EFB teil?
(3) Steht der gesundheitsorientierte Fitnessstatus, gemessen über den EFB, in Beziehung zu der Gesundheit der Teilnehmenden?

(1) Wie bewerten Testleitende, Teilnehmende sowie Experten und Expertinnen das EFB Konzept (Gesamt, Testprofile, Testaufgaben)?

Projektleiter des Projekts “European Fitness Badge (EFB) – a way of health promoting physical activity” ist der Deutsche Turner-Bund (DTB). Der DTB entwickelte das EFB gemeinsam mit einer internationalen Partnerschaft in einer ersten Projektphase bis 1. Juni 2017. Zwei Testprofile mit entsprechenden drei Level bilden das EFB, um den Fitnessstatus beurteilen zu können. Das Konzept der gesundheitsförderlichen körperlichen Aktivität (health-enhancing physical activity, HEPA) diente als Orientierung für die Bewertung der Testergebnisse sowie für die anschließende Beratung.

Zur Überprüfung der Akzeptanz, Machbarkeit und Gütekriterien beider Testprofile wurde im März und April 2016 eine Studie durchgeführt. 86 Teilnehmende (TP1: N = 22, Alter = 24 - 76 Jahre; TP2: N = 64, Alter = 26 - 67 Jahre) führten den EFB mithilfe von sechs Testleitenden durch. Die Teilnehmenden führten das EFB zwei Mal mit einer Woche Pause dazwischen durch. Die Wiederholungsmessung in

der zweiten Testwoche führten noch 19 Teilnehmende in TP1 und 60 Teilnehmende in TP2 durch. Hinsichtlich der Validität wurde ein Expertenrating der Testaufgaben durchgeführt (N = 16).

Die Ergebnisse der Evaluation zeigen positive Tendenzen hinsichtlich der Gütekriterien (Objektivität und Reliabilität: 67 – 100% Übereinstimmung in TP1 und r = 0,70 – 0,93 in TP2) sowie Akzeptanz (5-stufige-Skala: M = 1,5 (SD = 1,4) in TP1 und M = 1,5 (SD = 1,2) in TP2) und Machbarkeit (5-stufige-skala: M = 1,5 (SD = 1,8) in TP1 und M = 1,4 (SD = 0,6) in TP2) bewertet durch Teilnehmende, Testleitende und Experten und Expertinnen. Die Ergebnisse sind allerdings vorsichtig zu betrachten, da es sich hier um eine kleine Stichprobe mit großem Altersbereich handelt.

(2) Wer nahm am EFB teil?

Bezogen auf den Fitnessstatus erwachsener Europäer gibt es widersprüchliche Berichte, teilweise auch aufgrund einer fehlenden standardisierten Fitness-Testbatterie in ganz Europa. Das EFB wurde 2017 als online-basiertes Instrument zur Messung der gesundheitsorientierten Fitness erwachsener Europäer entwickelt. Diese Arbeit untersucht die demografischen Eigenschaften sowie den Fitnessstatus der Personen, die zwischen Juni 2017 und Mai 2019 am EFB teilgenommen haben.

Die multinationale Studie wurde in acht europäischen Ländern durchgeführt. Die Teilnehmenden führten das EFB unter Beobachtung einer Testleitung in verschiedenen Settings durch (z.B. Sportvereinstrainings, öffentliche Events). Das EFB beinhaltet elf validierte Testaufgaben zur Messung der Ausdauer, Kraft, Koordination und Beweglichkeit. Zwei Testbatterien (Testprofile, TP) erlauben die Unterscheidung von wenig aktiven (TP1) und aktiven Personen (TP2). Wir berechneten deskriptive Statistiken und führten Varianzanalysen durch, um Eigenschaften der Stichprobe herauszufinden sowie den möglichen Einfluss von Geschlecht, Alter, Body Mass Index (BMI), körperlicher Aktivität und Körperhaltung bezogen auf die Fitness (gemessen über das EFB) zu prüfen.

Die Stichprobe beinhaltet 6019 Erwachsene (68,7% weiblich; Durchschnittsalter 52,7 Jahre; Altersbereich 18 – 89 Jahre). Teilnehmende des TP1 waren älter (TP1: 61,4 Jahre; TP2: 44,2 Jahre; p = 0,00), berichteten ein geringeres Level an körperlicher Aktivität (TP1: 3,8; TP2: 4,0; p = 0,00), hatten einen höheren BMI (TP1: 25,7; TP2: 24,3; p = 0,00) und eine höhere Zahl an Abweichungen von der gesunden Körperhaltung (TP1: 43%; TP2: 33%; p = 0,00) als Teilnehmende des TP2. Von den 3034 Teilnehmenden des TP2 zeigten Männer bessere Leistungen in den Bereichen Ausdauer, Kraft, und Gesamt-Fitness, wohingegen Frauen bessere Leistungen bei der Koordination und der Beweglichkeit zeigten. Zudem hängt ein jüngeres Alter, ein geringerer BMI und ein höheres Level an körperlicher Aktivität mit besseren Ergebnissen bei den EFB Tests zusammen.

Das EFB ist ein Instrument zur Feststellung der gesundheitsorientierten Fitness erwachsener Europäer. Unsere Ergebnisse zeigen, dass die Profile TP1 und TP2 von den entsprechenden Zielgruppen durchgeführt wurden und bestätigen die Ergebnisse vorheriger Studien bezogen auf mögliche Determinanten der Fitness wie Geschlecht und Alter.

(3) Steht der gesundheitsorientierte Fitnessstatus, gemessen über den EFB, in Beziehung zu der Gesundheit der Teilnehmenden?

Ein solider Forschungsstand besteht, dass Fitness eine körperliche Gesundheitsressource darstellt, die dazu dient, die Gesundheit zu schützen. Es beseht jedoch weiterhin Uneinigkeit darüber, welches Fitnesslevel die beste Gesundheitswirkung hat und welche Messinstrumente dafür dienlich sein könnten. Diese Querschnittsstudie analysierte 462 (64,07% weiblich) mittelalte Deutsche hinsichtlich ihres Fitnessstatus, ihrer körperlicher Aktivität (Non-Exercise Test), ihrer Körperkonstitution (Body Mass Index, BMI) und ihres koronaren Gesundheitsstatus. Die gesundheitsorientierte Fitness wurde über motorische Tests gemessen. Der koronare Gesundheitsstatus wurde über einen Fragebogen und teilweise durch einen Arzt diagnostiziert. Zusammenhänge zwischen Risikofaktoren und Fitnessfaktoren wurden während der Korrelationsanalyse sichtbar (Korrelation zwischen 0,17 und 0,46). Sie wurden deutlich sichtbar beim Vergleich von Personen mit und ohne Risiko. Personen mit niedriger Fitness zeigen auffallend mehr Risiko bei der Aktivität (Männer = 36 – 58%, Frauen = 38 – 43%), beim BMI (Männer = 19 – 26%, Frauen = 10 – 22%) und dem koronaren Gesundheitsstatus (Männer = 19 – 26%, Frauen = 10 – 22%). Personen mit hoher Fitness zeigen Gesundheitsressourcen hinsichtlich Aktivität, Body Mass Index und koronarem Gesundheitsstatus. Diese Studie zeigt den positiven Einfluss aller Fitnessdimensionen auf den koronaren Gesundheitsstatus. Fitness wurde objektiv gemessen und beinhaltet die gesundheitsorientierten Fitness-Dimensionen Ausdauer, Kraft, Koordination und Beweglichkeit.

Insgesamt ist das EFB ein internationales Instrument zur Darstellung der gesundheitsorientierten Fitness der europäischen Bevölkerung, mit bestimmten Einschränkungen. Derzeit ist das EFB der einzige multinationale Fitnesstest für Erwachsene in Europa. Konzept, wissenschaftlicher Hintergrund, Ziel und Zielgruppe wurden überprüft und als gut bewertet oder entsprechend angepasst. Nach zwei Jahren realer Testdurchführungen wurden die Teilnahmedaten hinsichtlich der gesundheitsorientierten Fitness analysiert. Dies muss weitergeführt werden. Durch zusätzliches Marketing sowie nationalen und internationalen Verbreitungsstrategien können Limitationen wie die unterschiedlichen nationalen Stichprobengrößen verringert werden. Strategien und Konzepte für spezielle und relevante Zielgruppen wie inaktive Personen müssen in die Praxis umgesetzt werden.

Die Weltgesundheitsorganisation (WHO) hat das Ziel gesund zu bleiben oder zu werden als gemeinsames internationales Interesse benannt. Dieses Interesse kann nur mit der Integration aller gesundheitsbezogenen Bereiche geschehen. Die Interaktion zwischen Sport, körperlicher Aktivität und Fitness ist ein Aspekt dieses komplexen Konstrukts. Sollte der EFB an diesem komplexen Konstrukt zur

Aktivierung und Motivation von Personen teilhaben können, ist das Ziel des EFB und seiner Entwickler erreicht.

1. General Introduction

"The lack of physical activity in our modern lifestyles leads to major health problems and costs our economies billions. We can all be active in different ways - from taking a short walk to running a marathon. I am calling on everyone to join us in the European Week of Sport." Tibor Navracsics, European Commissioner responsible for Sport, opened the fifth European week of Sport (EwoS) in 2019 with those words. This is a motivation to reach all people to contribute to physical activity in general, irrespective of abilities and opportunities to join.

Physical inactivity and sedentary behaviour are among the main risk factors for various non-communicable diseases such as cardiovascular diseases or metabolic syndrome (Katzmarzyk, 2010; Lee et al., 2012; Thorp et al., 2011; Wen et al., 2011). These diseases are associated with high economic burden as they often lead to loss of work force or early retirement (Ding et al., 2016). Physical inactivity and sedentary behaviour are highly prevalent in Europe, i.e., 46% of Europeans never engage in physical exercise or sport activities and this number has increased over the last ten years (European Commission, 2018).

One way to potentially impact people's health-related behaviour and motivate them to maintain or adopt an active lifestyle are individually-tailored programmes such as cardio or aerobic exercise programmes. However, a prerequisite for a successful exercise program is a valid diagnosis of the current fitness status of a person (Godino et al., 2014). To this end, various fitness tests are used in Europe such as the German Sports Badge (Deutscher Olympischer Sportbund (DOSB), n.d.), the Austrian Sport and Gymnastic Badge (Bundesministerium für Kunst, Kultur, öffentlichen Dienst und Sport, n.d.) or the Eurofit test for adults (Oja & Tuxworth, 1995). Nevertheless, no international fitness test reached a broad European adult population.

In 2014, Prof. Dr Walter Brehm, Pia Pauly and Prof. Dr Klaus Bös had the idea of a Europe-wide fitness test. The idea of a health-related fitness test based on a strong partnership and collaboration beyond borders developed (2015 - 2017), published (2017) and improved (2017 - 2019) the EFB.

This thesis is one milestone on the further path of the EFB and the consortium. It concludes the last four years of funding (ending point) and heralds the start of the EFB future (starting point). Aim of this thesis is to execute a broad evaluation of the EFB and displaying the health-related fitness status of eight European countries.

1.1. Aim and structure

The main aim of this thesis is to present the European health-related fitness status according to the evaluation of the EFB. The evaluation of the EFB is one main aim of the second funding phase.

To reach this aim, a strong evaluation and examination is executed. Therefore, the outline of the thesis is displayed in Figure 1-1.

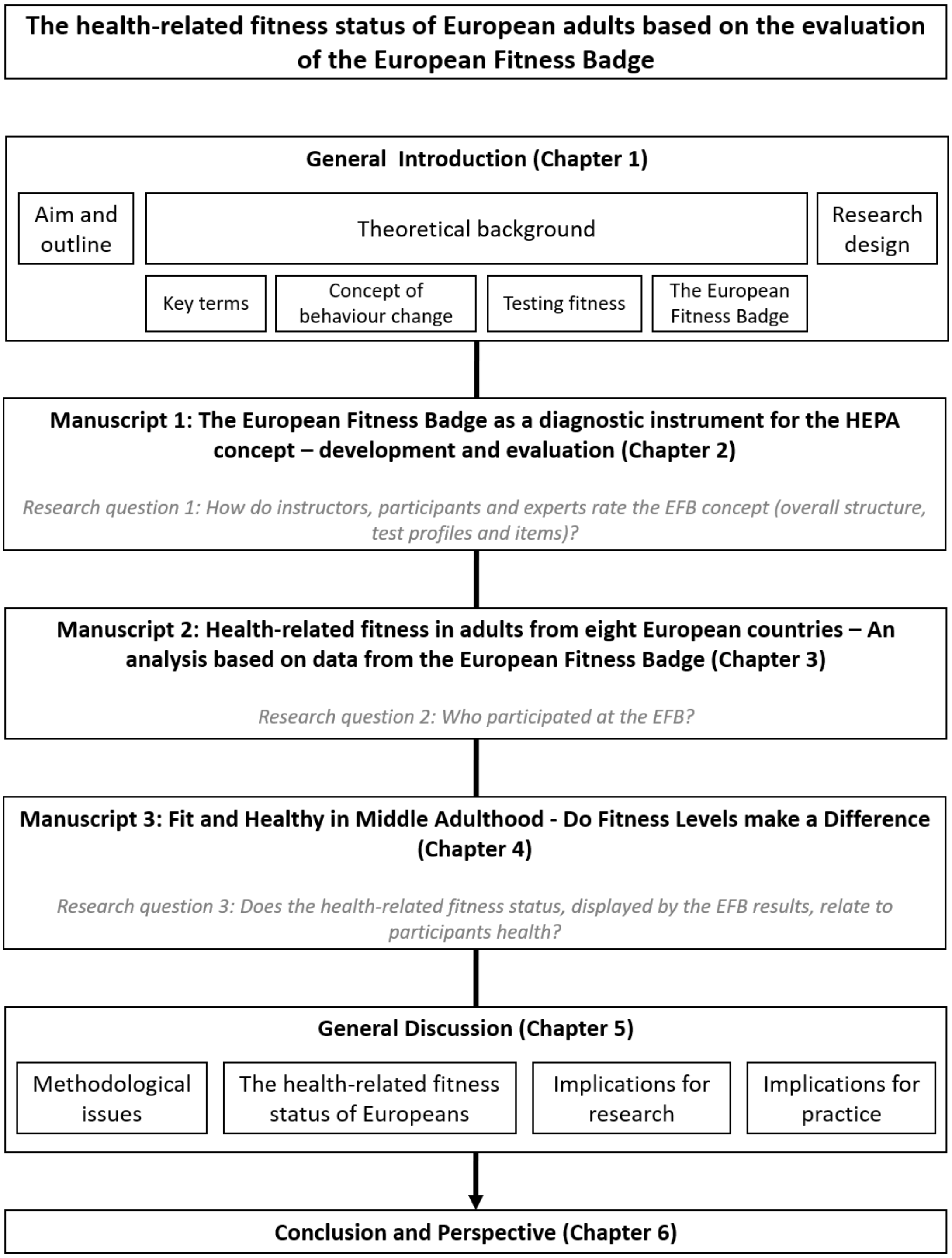


Figure 1-1 Structure of the thesis

Chapter 1 presents the theoretical background of this thesis. Key terms and underlying concepts regarding behaviour change and fitness testing are presented in detail for the understanding of the EFB. Based on this, the EFB itself is presented in short in the following chapter. The last part of chapter 1 describes the research design including the research questions connecting the manuscripts to the overall topic of the thesis.

Chapter 2 presents the first of the three manuscripts. This manuscript describes and analyses the concept of the EFB as a first evaluation step. The aim was to cause a scientific basis regarding the test battery including feasibility, acceptance and psychometric properties of the EFB. The scientific basis of different evaluation methods involves the relevant stakeholders of participants, instructors and internal and external experts.

Chapter 3 presents the second of the three manuscripts. This second step of evaluation was the analysis of participants two years after implementation. Main two question were, (1) who is reached by the EFB and (2) if the EFB reaches its target groups. Focus was the sustainable outcome evaluation.

Chapter 4 presents the third of the three manuscripts. After the proof of the test battery in the first step and the analysis of the participants, the third step of evaluation was to prove if the EFB separates fit and non-fit participants plus if it displays a health-related badge.

Chapter 5 presents the general discussion. The concluding aim of this thesis is the perspective the EFB has on the following two levels: scientific and practical. Therefore, concrete implications for researchers and practitioners enable a continuation of the EFB in the common sense of collaboration between science and practice. In relation to the general discussion and the methodological issues, these implications are part of this chapter.

Chapter 6 concludes the thesis by providing an overview of the output as well as a future perspective on fitness testing in Europe and its relationship to enhance physical activity in the European population.

1.2. Theoretical background

For a comprehensive understanding of the thesis issue, the underlying key terms, key concepts and backgrounds regarding fitness testing and the EFB as fitness test are described in this chapter.

1.2.1. Key terms

"However, they are often used confused with one another, and the terms are sometimes used interchangeably." This statement by Caspersen et al. in 1985 about fitness, physical activity and exercise is still effective. Therefore, for a full understanding and transparency of this thesis, some terms are defined in detail. These following terms are defined to the best of the author's knowledge. Controversial definitions are named if there is a current scientific discussion.

Physical activity

Physical activity is every bodily movement that is produced by the skeletal muscle that results in energy expenditure (Bouchard & Shephard, 1994; Caspersen et al., 1985). This definition includes every bodily movement during every time of the day. Recently, Piggin (2019) defined a new and broader definition of physical activity. He emphasizes the diversity, interdisciplinarity and inclusion of physical activity and acknowledges the wide range of reasons for people to be active. Those two definitions are not mutually exclusive, mor than this the newest definitions includes the established one and broadens the definition according to the modern understanding of being physically active.

Many different forms of physical activity are defined. These definitions mostly follow the setting approach (leisure time, work time, active transport) or the approach of energy expenditure (low, moderate, vigorous). (Caspersen et al., 1985; Hallal et al., 2012) The World Health Organization (WHO) recommendations of Physical Activity concentrate on the second one (World Health Organization, 2010). Their recommendation includes

- at least 150 minute of moderate-intensity aerobic physical activity or at least 75 minutes of vigorous-intensity aerobic physical activity per week,
- physical activity bouts of at least 10 minutes duration,
- Muscle-strengthening activities, which involve major muscle groups on 2 or more days a week,
- and additional health benefits can be reached with an increase of moderate-intensity aerobic physical activity up to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week. (World Health Organization, 2010)

All western continents published Physical Activity Guidelines in the last 30 years (Australian Government Department of Health, 2014; European Commission, 2008; Pfeifer & Rütten, 2017; Tremblay et al., 2011). In the EU, 23 out of 28 member states published their own physical activity recommendations (Gelius et al., 2020). They all are based on the recommendations of the WHO.

Physical fitness

Bös & Schlenker (2011) define physical exercise as the so-called training, which is structured and planned physical activity. In fact, it aims to maintain or improve components of physical fitness. This means, an increase in physical activity produces and increases physical fitness (Blair et al., 2001).

In 1985, Caspersen et al. provided the definition of physical fitness in their popular paper as “a set of attributes that people have or achieve”. A model of physical fitness published 15 years later, describes components of physical fitness in three subcategories: physiological fitness, skill-related fitness and health-related fitness. Physiological includes e.g. metabolic and bone integrity, skill-related includes among others speed, agility and reaction time and health-related fitness body composition, flexibility and far more which will be describe in the next section. (Corbin et al., 2000)

Woll (2006) defines fitness as a physical health resource, which serves as protecting issue of health. A high fitness level means an important health resource especially for people in the middle or late age (ibid.).

In the 1980s, research groups around Pate and Caspersen tried to define physical fitness and to find subcategories. Since then, the differentiation of performance-related fitness and health-related fitness is commonly used. (Biddle & Mutrie, 2007; Caspersen et al., 1985; Pate et al., 1989; Vanhees et al., 2005) According to the aim of this thesis, focus will be on health-related fitness.

Health-related fitness

Health-related fitness is a component of physical fitness, which evolved out of the examined relationship among fitness, health and physical activity (Malmberg et al., 2002; Suni et al., 1998). Physical activity favourably affects health-related fitness whereas sedentary behaviour unfavourably affects it (Bouchard et al., 2012).

Referring to the main term health-oriented fitness describes a state, which empowers people to live a vital life with a low risk of chronical diseases or premature death (Caspersen et al., 1985; Pate et al., 1989). Based on literature, the most important components of health-related fitness are cardiorespiratory fitness (endurance), muscular fitness (strength), coordination and flexibility (Bös & Mechling, 1985; Caspersen et al., 1985; Oja, 1991; Samitz & Baron, 2002; Suni et al., 1998). Often other components, especially body composition and posture, are added to this health-related understanding of fitness (ibid.).

Bouchard and Shepard (1994) broaden this definition in their concept of health-related fitness. In their understanding, health-related fitness includes those components, but it depends on far more aspects as genetics, physical activity and further environmental factors. Physical activity includes all activity executed in leisure time, occupational time and during training and sports. Further environmental factors include lifestyle behaviours, personal attributes, physical and social environment. Bringing all together, these are directly linked to the health of a person including wellness, morbidity and mortality. (Schmidt et al., 2017; Vanhees et al., 2005)

The concept of health-enhancing physical activity evolved out of this research and the need of physical activity promotion.

Health-enhancing physical activity (HEPA)

In 2005, HEPA Europe, the European Network for the Promotion of Health-Enhancing Physical Activity, was founded in Denmark (Martin et al., 2006). Since then interested European organisations and institutions have joined the network to work together on the aim "to develop, support and disseminate effective strategies, programmes, approaches and other examples of good practice" (ibid.) for the promotion of HEPA.

HEPA behaviour recommends, regarding adults, to have regular active sessions for at least 150 minutes per week – even better – with moderate intensity (Oja, 2008; World Health Organization, 2010). The HEPA concept leading to this HEPA behaviour is described in chapter 1.2.2.

Health

Defining health is challenging due to flexible definitions of disease and progress in treating them on the one hand and developing resources on the other hand (Hardman & Stensel, 2009). The WHO (1986) defines health as a concept emphasizing social and personal resources as well as physical capacities. Antonovsky (1996) adds that physical, social and psychological dimensions are characterized on a continuum with positive and negative poles. Hence, health is not just the absence of disease but the capacity to enjoy life and to withstand challenges (Bouchard & Shephard, 1994). Becker et al. examined parameters influencing health in their study over 20 years ago and named them "health-related variables" (Becker et al., 1996). Existing current literature in the context of fitness and activity mostly concentrates either on the understanding of health in physical context (mortality, body composition, blood values etc.) (Warburton, 2006) or on the understanding of health in a psychological context (well-being, enjoying life) (Bize et al., 2007; Olivares et al., 2011).

For the definition of health the WHO stated the following sentence: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (World Health Organization, 1946). In addition, health is multifactorial and complex (Bouchard et al., 2012) and it is the right of every human being to have the "highest attainable standard of health" (World Health Organization, 1946). Furthermore, the constitution of the WHO indicates that governments are responsible to provide proper health actions for their people (ibid.). For example, measures to increase the fitness of the people.

Badge, test, test profile, test battery, test item

The usage of the name European Fitness *Badge* evokes the impression of something to achieve, a certificate, a test to pass. The term *test* on the other hand is associated closely to the school or university setting and a rather negative related term for most of the people. *Badge* has been chosen to evoke a motivating attitude to achieve the Europe-wide fitness badge.

Talking about the content of the EFB, the terms *test profile* and *test battery* will occur. A test profile is defined as a pool of multi-dimensional and complex test items. The International Physical Performance Test Profile (IPPTP) of Bös & Mechling (1985) is such a test profile, which contains heterogeneous *test items*. These items are evaluated after individual results. A pool of homogeneous test items builds a test battery. This differentiation is not strictly adhered to the practical field of tests like presented at the German Motor Test (DMT) manual (Bös, 1987; Bös & Schlenker, 2011). In case of the EFB, there is talk of two test profiles with seven *test items* each. Test items can be structured in different dimensions, which Bös pictured out through the taxonomy of sport motoric test items (Bös & Schlenker, 2011; Lämmle et al., 2010).

In respect of the term *test item*, it must be attended, that it is sometimes used similar with the word test. Especially in the German language, a test sometimes means a test item and not a whole badge.

Further analysis of these terms related to fitness are displayed in chapter 1.2.3.

1.2.2. Concept of behaviour change

Behaviour change reflects a long process including several different stages and is influenced by correlates of knowledge, motivation, emotions, social support and group integration (Duan et al., 2013). The concept of change in health behaviours is historically based on the Transtheoretical Model by Prochaska and DiClemente (1982). They investigated the change of behaviour in psychotherapy. According to them, the change of the individual, their will to change and their current stage of behaviour is a very important factor to succeed in behaviour change. Apart from the engagement of the therapist, the reflection of the individual is important. They therefore developed four stages of change: 1) thinking about 2) becoming determined 3) actively modifying 4) maintaining. These stages show a theoretical model and do not follow a strict process but a dynamic process. (Ibid.) Meanwhile, the model changed through further research and integration of further behaviour models by Freud and Skinner (Prochaska & Velicer, 1997) into five stages of change which are displayed in Table 1-1. The according processes are the processes, which need to be applied in this stage for progressing.

Table 1-1 Stages of change with according processes (after Prochaska & Velicer, 1997)

	Stages of change				
	Precontemplation	**Contemplation**	**Preparation**	**Action**	**Maintenance**
Processes	Consciousness raising Dramatic relief Environmental re-evaluation				
		Self-Re-evaluation			
			Self-liberation		
				Contingency management Helping relationship Counterconditioning Stimulus control	

This model has been transferred to many other settings and sciences in the health context (Prochaska et al., 1994). In physical activity context, the FIT model of HEPA is the most common one.

The FIT (**F**our steps from **i**nactivity to health-enhancing physical ac**t**ivity) model of HEPA (cf. Figure 1-2) defines the change of behaviour, according to the five stages of the Transtheoretical Model (Prochaska & DiClemente, 1982), from "not considering" (stage 1) to "maintaining" (stage 5) physical activity (Duan et al., 2013). Duan and colleagues show evidence of this model and have examined the links between health and psychosocial correlates within an international study based on data from 2071 adults (ibid.). The first three stages describe the motivational part of a person towards being active, where no HEPA behaviour takes place so far. The next two stages characterize HEPA behaviour as being active more than 150 minutes per week, oriented on the physical activity recommendations of the WHO (cf. chapter 1.2.1). At stage 4 “Exploring” it is necessary to strengthen a sustainable active HEPA behaviour whereas at stage 5 the activity level continues at the same level. (Ibid.)

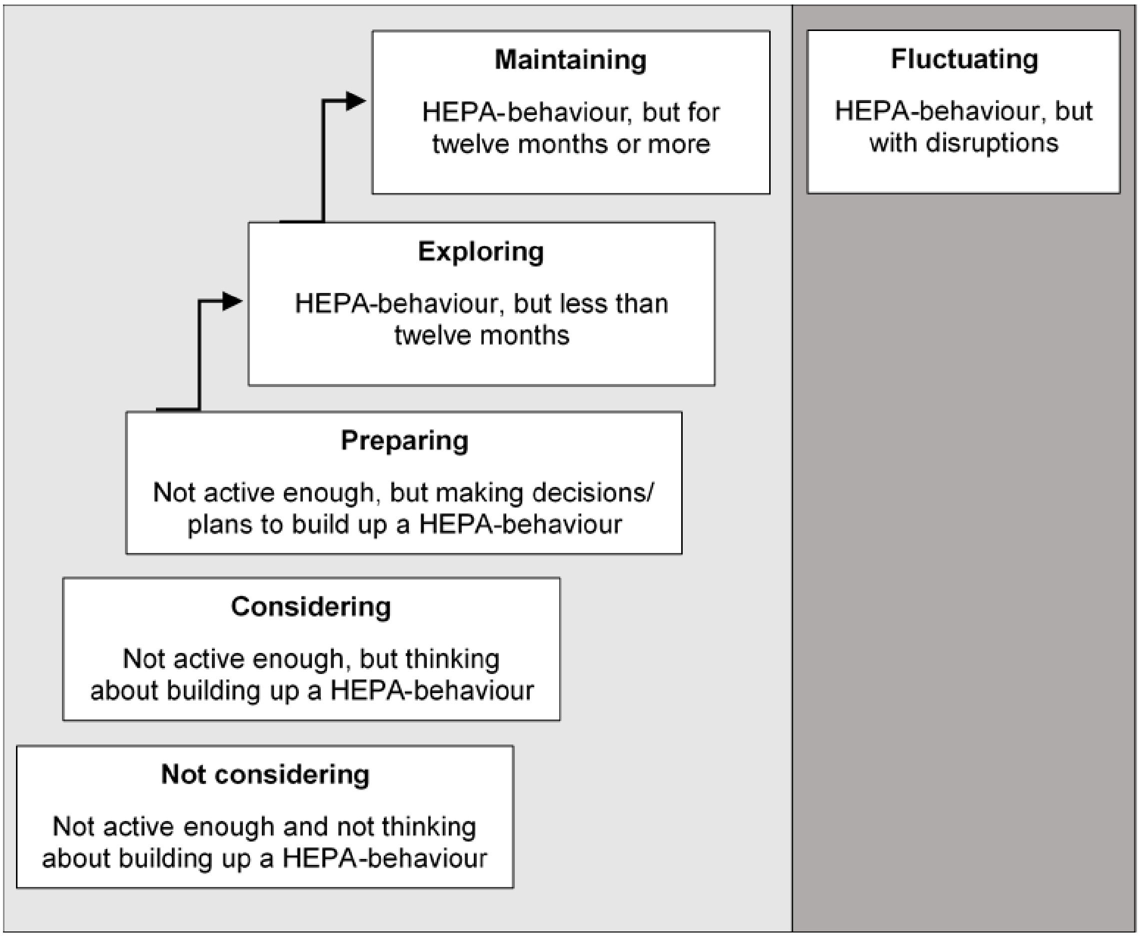


Figure 1-2 The FIT model of HEPA (own illustration after Duan et al., 2013)

Knowledge about those stages and recognizing them is an important part of enhancing physical activity. To have a concrete individual stage and aiming to rise this is as important as knowing the objective fitness status. Therefore, the combination between the HEPA concept and testing fitness is a sustainable strategy in activity promotion.

1.2.3. Testing fitness

Testing physical fitness is an important factor for planning and evaluating interventions in different research fields. In the last years, the scientific community asked for objective measurements, not only for physical activity but for physical fitness in particular (Godino et al., 2014; Kokkinos et al., 2017). The lack of valid and objective measurements leads to an overestimation and non-realistic impression of physical activity and physical fitness status. With an objective and understandable test of physical fitness, practitioner and researcher work out strategies and interventions in a realistic way. (Ibid.)

Vanhees et al. (2005) offer an overview of criterion-based methods, objective methods and subjective methods in measuring physical activity and physical fitness. Their demand is an increased usage of tests with an overall good psychometric (including objectivity, standardization, validity, reliability, available reference values) (ibid.).

The Eurofit for adults (Oja & Tuxworth, 1995) is a test battery which relies on this. It is based on the definition of physical fitness in a health-oriented way. Therefore, the research group around Oja & Tuxwurth developed the Eurofit according to the model of health-related abilities by Bouchard and Shephard (1994). Their assessment of health-related fitness consists of ten different test items measuring condition-determined and coordinative-determined abilities. In addition, the test battery includes five anthropometric measurements.

In Germany, test batteries of most common fitness tests (e.g. German Sport Badge, German Motor Test) are based on the model of motor performance abilities by Bös (Bös, 1987; Lämmle et al., 2010). This model focuses on the motor fitness components, which are differentiated in conditional and coordinative determined abilities. However, these test batteries have a great difference in the used test items. The German Sport Badge includes mostly sports-related test items as swimming or throwing (Deutscher Olympischer Sportbund (DOSB), n.d.), whereas the German Motor test, as the Eurofit, includes motor performance test items (Bös & Schlenker, 2011).

There are many more existing fitness test batteries with different objectives in what and who to test. This emerges out of the different approaches of defining physical fitness (see chapter 1.2.1). In manuscript 1 (cf. chapter 2) results of a research of existing tests and badges as well as the model of performance-oriented motor abilities by Bös are displayed in full length.

The following chapter describes the new developed EFB as fitness test regarding health-related fitness for adults residing in Europe.

1.2.4. The European Fitness Badge

The EU Erasmus+ programme has funded the project "European Fitness Badge (EFB) – a way of health promoting physical activity" from 2015 to 2019. The international project team, headed by the German Gymnastic Federation (DTB), established the badge during the first project period ending July 1st, 2017. (Klemm et al., 2017) Involved partners are sport associations in the field of grassroots sport and scientific institutions from Germany, Belgium, Denmark, Austria and Spain. The second project period ended December 31st, 2019. Two partners from Bulgaria and Slovenia joined this second period for further dissemination.

Aim of the EFB is to reach people of every activity level to test their fitness. With testing fitness and the following counselling, a rise of the fitness level or a maintenance of a high fitness level is achieved. The target group are adult people in every setting (sport club, fitness club, company etc.) with every activity level (from no activity to high activity). The project group focusses especially those two target groups:

1) Inactive or low active people, who need to be motivated for activity or have already a small motivation level and just need concrete starting points. They are located at HEPA stages 2 or 3.
2) Active people, who want to have an assessment of their performance. They are located at HEPA stages 4 or 5. (Bös et al., 2017)

Therefore, two test profiles with three corresponding levels for awarding the fitness status were developed. Those two test batteries are, as other fitness tests before (cf. chapter 1.2.3), based on the model of motor performance abilities by Bös (Bös, 1987; Lämmle et al., 2010). Test profile 1 is function-oriented and contains test items, which focus on daily life (e.g. standing up with one leg). The scoring ranges from 1 to 3 points and is the same for people of every age and sex. The achieved overall score is evaluated for age. EFB level 1 called "Basic" can be achieved with this test profile. Test profile 2 is performance-oriented and contains test items which are based on maximum performance (e.g. as many push-ups as possible in 40 seconds). The scoring depends on sex- and age-related reference values and differentiates in quintiles. EFB level 2 named "Advanced" and level 3 named "Approved" can be achieved with this test profile. Both test profiles include further measurements for physical activity, body composition, body posture and body stability, which are not part of the scoring but serve for a comprehensive description of the health-related fitness status on individual level. All test items and additional measurements are broadly displayed in manuscript 1 (cf. chapter 2). An overview about the EFB test structure is shown in Figure 1-3.

TP	Dimension	Test items	Evaluation	Total points	Result
Test profile 2	Endurance	Step test Walking test	1-5 points/test according to reference group (age, sex) percentile, mean per dimension if > 1 test item is performed	4-20 points	≥15 points → **Level 3: Approved**
	Strength	Push-up Jump & reach			≥11 points → **Level 2: Advanced**
	Coordination	Walking backwards Flamingo balance			
	Flexibility	Sit & reach			
	Additional measurements	Activity Body composition Posture Body stability	Additional comment, not part of evaluation		
Test profile 1	Endurance	Step test N-Ex	1-3 points/test according to scoring based on reference values, mean per dimension if > 1 test item is performed	4-12 points	≥ 7 – 11 points according to age → **Level 1: Basic**
	Strength	Push-up Standing up			
	Coordination	Jumping jack Balancing on one leg			
	Flexibility	Sit & reach			
	Additional measurements	Activity Body composition Posture Body stability	Additional comment, not part of evaluation		

Figure 1-3 EFB test profiles with according test items, evaluation, scoring and results

Test items are chosen due to good psychometric properties examined in different national studies. A detailed description of these psychometric properties is presented in the handbook for instructors (Bös et al., 2017).

1.3. Research design

The research design is strongly oriented to the EU Erasmus+ application of the project group. In this application for the second funding phase from 2018 to 2019, evaluation of the EFB is one of three main targets: Implementation, dissemination and evaluation. Therein, evaluation of the following aspects is described: participation, target groups, fitness-status, test items, instructors and settings. These serve as evaluation criteria for the following descriptions.

During the ongoing working process, these aspects were redefined and discussed in-between the project group and in-between the scientific subgroup. The development of the participant numbers, overall, after test profile and after country, as well as the potential involvement by the project partners were facts to consider. Three main evaluation aspects emerged out of these discussions and processes. Those are displayed in an evaluation scheme in Figure 1-4.

The concept of the EFB is the first aspect. The overall structure, test profiles as test batteries and the according test items are part of the concept evaluation. These parts need to be evaluated by all involved group of persons; the instructors, the participants, internal and external experts. The concept of the EFB is the basis of all further evaluation aspects. In some points, the further aspects depend on the concept and the detailed evaluation of it.

Second aspect is the analyses of the participants. To have a definite statement about the success of the EFB the overall sample is to observe regarding the real numbers of participants, the original country of them, the target group they fit in and their fitness status. Therefore, a very detailed description of the sample is the aim in this part of the evaluation.

Third aspect is the target group of the EFB. The target group depends strongly on the concept of the EFB. The concept itself determines the target group. In this case, the target group are adults, which are or want to be healthy through physical activity. They find themselves on every activity and fitness level, from no activity to high activity, from low fitness to high fitness, but according to the HEPA stages at least think about getting active. Evaluation of this aspect focusses on the reached participants and analyses the characteristic of the sample regarding health, activity and fitness status.

It must be considered that an international project with such a large target group has much more aspects to consider during evaluation. The instructors themselves and all related aspects like education or test material, the settings the EFB is integrated in, the developers and their background and aims for now and the future plus the impact and sustainability of the EFB are further aspects for example. These aspects are not considered in this thesis but have been considered by the project group. They are part of small studies in single countries or part of student studies, which are not published until now.

Figure 1-4 Evaluation scheme of the EFB

As consequence of the evaluation scheme, the evaluation process was divided into three steps: (1) Evaluation of the overall concept of the EFB, (2) Evaluation of the participants and (3) Evaluation of the target group.

For every step, a study was conducted, and an according manuscript was published describing the methods, results and discussion of this study in detail. The overall research aim of the thesis is the evaluation of the EFB. Out of the named evaluation aspects and according to the three steps named before, following research questions evolved:

- How do instructors, participants and experts rate the EFB concept (overall structure, test profiles and items)?
- Who participated at the EFB?
- Does the health-related fitness status, displayed by the EFB results, relate to participants health?

These research questions leaded to the following three studies:

1) **The European Fitness Badge as a diagnostic instrument for the HEPA concept – development and evaluation**. This study focusses on the EFB concept from the point of view of all involved groups: participants, instructors and experts. Theoretical background were an analysis of existing tests and badges as well as the analysis of the HEPA concept. Altogether, a sample of 86 participants from Germany, six test instructors from Germany and Belgium and 16 test experts from Germany, Belgium, Denmark and Austria took part at this test-retest study.
2) **Health-related fitness in adults from eight European countries – An analysis based on data from the European Fitness Badge**. Data of fitness test results and relevant parameters (according to

health and activity) are presented and reflected in this cross-sectional study. Background was the non-existing fitness data sample of European adults. Data of > 6,000 participants from eight European countries were analysed.

3) **Fit and Healthy in Middle Adulthood - Do Fitness Levels make a Difference**. As stated in the title, this cross-sectional study concentrates on the health orientation of the EFB. The study was based on the model of health-related fitness by Bouchard, Blair and Haskell (2012). With a sample of 462 middle aged adults the health issues according to the fitness status were examined for proving the reach of the target group.

The following three chapters display those three studies as the original published manuscripts.

2. Manuscript 1: The European Fitness Badge as a diagnostic instrument for the HEPA concept – development and evaluation

Published as Klemm, K., Brehm, W., Bös, K. (2017). The European Fitness Badge as a diagnostic instrument for the HEPA concept – development and evaluation. Leipziger Sportwissenschaftliche Beiträge, 58(2), S. 83-105.

2.1. Abstract

The project European Fitness Badge (EFB) – a way of health promoting physical activity is funded by the European Union Erasmus+ programme since 2015. The international project team, headed by the German Gymnastic Federation (Deutscher Turner-Bund), established the badge during the first project period ending July 1st, 2017. Two test profiles with corresponding three levels for awarding the fitness status were developed. The Health-Enhancing Physical Activity (HEPA) concept served as an orientation for the evaluation of the test results as well as the following counselling. Overall, the test items show high statistical values concerning the psychometric properties objectivity, reliability and validity. The concept is feasible and well-accepted by instructors and participants. The EFB as a test available for participants started in May 2017 and is executed in all partner countries, gathering information about the fitness level of European citizens. The second project period, which is focussing in the further dissemination and the Europe-wide evaluation, will begin in January 2018.

2.2. Introduction

The European Fitness Badge (EFB) is the result of an EU-funded project in collaboration of six European sport organizations and universities. The project group developed this health-oriented fitness badge from 2015 to 2017 with the objective of establishing an instrument for sport and health organizations to enhance the awareness of the importance of a health-enhancing fitness status. Besides the function as a global health-promoting instrument, the EFB displays an instrument to confirm the fitness status of the adult population individually.

This paper aims to:

- give a short overview about existing tests and badges in Europe (cf. chapter 2.3);

- explain the HEPA concept as the basis behind the EFB (cf. chapter 2.4);

- describe and justify the EFB as a diagnostic instrument for the HEPA concept (cf. chapter 2.5);

- describe and discuss the first evaluations of the EFB; (cf. chapter 2.6)

- show perspectives for the further improvement and dissemination in Europe (cf. chapter 2.7).

2.3. Overview about existing tests and badges in Europe

Ahead of developing the detailed test concept of the EFB, a research of existing sport and fitness badges and test batteries was conducted. In January and February 2015, the following online databases were integrated in the search: PubMed (www.ncbi.nlm.nih.gov/pubmed), ViFa Sport (Virtual technical library of Sport Science, www.vifasport.de) and BiSp (German Federal Institute for Sport Science, www.bisp-surf.de/discovery). In addition, the international ministries of sports and their websites were browsed through. In the last step, personal contacts of the project team in Hungary and Finland were contacted and interviewed. The following keywords were used in English, Spanish, German and French: Fitness OR Sports test, Fitness OR Sports badge, Army OR Military test, Fitness/Sports test AND country, School fitness test AND country, Test battery for sport, Physical exam OR test, Evaluation for physical skills. Only well-described and online accessible tests and badges, published in Europe after 1995, were included. Table 1 presents an overview.

Table 2-1 Existing tests and badges in Europe (Effective March 2015)

Overview about existing tests and badges worldwide	
Origin	Name
Austria	Österreichisches Sport-und Turnabzeichen (Austrian Sport and Gymnastic Badge)
Denmark, Norway, Sweden, Finland	Armed Forces Physical Fitness test
Europe	Europäisches Polizei Leistungsabzeichen (EPLA) (European Police Performance Badge) AE-COPSD Sport badge The Alpha Project Eurofit
Finland	Eurofit (for adults)
France	Test d'évaluation de la condition physique (Evaluation test for physical condition)
Germany	Deutsches Sportabzeichen (German Sports Badge) Deutschland bewegt sich Test (Germany is moving test) Deutscher Motorik Test (German Motor Activity test)
Hungary	NETFIT Hungary (Children)
Switzerland	Suisse sport test
UK	The National Fitness Test British Army Fitness Test

The identified fitness tests and badges differ regarding their overall concept, their target group, their aims and their scientific base. Not all tests are well-described for the public, and due to the content orientation of this paper, it is not possible to mention detailed information about every test.

Some of the tests consist of different achievable levels named gold, silver and bronze (e.g. "Austrian Sport and Gymnastic Badge", "German Sports Badge"). Further like the German Sports Badge (Deutsches Sportabzeichen) is designed for everyone, regardless of age and sex. Compared to the German Sports Badge, other badges include skill tests like swimming, cycling or shot-put (e.g. "Austrian Sport and Gymnastic Badge"), or focus on a test battery with motor ability tests like push-up, sit-up, vertical jump or shoulder movement (e.g. "Evaluation test for Physical Condition", "Eurofit" and "NETFIT"). Besides, some tests like the "Candidate Fitness Assessment" or the "AE-COPSD Sport Badge", combine these two aspects of test selection.

Concerning the target group, identified fitness tests contain a wide age range, from childhood (age of 6) to late adulthood (no age limit) (e.g. "German Sports Badge"). On one hand, some are only suitable for children and adolescents, e.g. "The Alpha Project" or "NETFIT". On the other hand, selected tests and badges are generated for adults in every age with different aims such as evaluating the general physical capacity (e.g. "Eurofit"), the motor functional state in health-related fitness (e.g. "Germany is Moving test") or to honour the performance in sports (e.g. "German Sports Badge", "Austrian Sport and Gymnastic Badge").

2.4. The concept behind the EFB: Health-Enhancing Physical Activity (HEPA)

Behaviour change reflects a long process including several different stages and is influenced by correlates of knowledge, motivation, emotions, social support and group integration (Duan et al., 2013). The concept of a change in health behaviours is historically based on the Transtheoretical Model by Prochaska and Di Clemente (1982). Among others, especially Marcus et al. (1994), Prochaska & Velicer (1997), Miilunpalo (2001) and Duan et al. (2013) linked this model to physical activity and the change of behaviour towards an HEPA behaviour (Miilunpalo et al., 2000). HEPA behaviour considers, regarding adults, to have regular active sessions for at least 150 minutes per week – even better – with moderate intensity (Oja, 2008; World Health Organization, 2010). Activities include the four health related abilities: endurance, strength, flexibility and coordination.

For motivating people in increasing their health-enhancing physical activity a differential feedback regarding the current status is necessary. This relates to the current activity level as well as the current fitness status of the health-related physical abilities. The diagnosis of fitness gains in importance, and a wide range of studies point out that fitness is a meaningful predictor for health. (Bös et al., 2012; Tittlbach et al., 2017)

In 2005, HEPA Europe, the European Network for the Promotion of Health-Enhancing Physical Activity, was founded in Denmark (Martin et al., 2006). Since then interested European organisations and institutions had join the network to work together on the aim “to develop, support and disseminate effective strategies, programmes, approaches and other examples of good practice” (ibid., p. 56) for the promotion of HEPA.

The FIT (Four steps from inactivity to health-enhancing physical activity) model of HEPA (cf. Figure 1-2) defines the change of behaviour, according to the five stages of the Transtheoretical Model of Prochaska and DiClemente (1982), from “not considering” physical activity (stage 1) to “maintaining” (stage 5) (Duan et al., 2013). Duan and colleagues are showing evidence of this model and have examined the links between health and psychosocial correlates within an international study based on data from 2071 adults (ibid.). The first three stages describe the motivational part of a person to-wards being active, where no HEPA behaviour takes place so far. The next two stages characterize HEPA behaviour as being active more than 150 minutes per week. At stage 4 “Exploring”, it is necessary to strengthen a sustainable active HEPA behaviour whereas at stage 5, the activity level need to continue at the same level. (Ibid.)

The EFB aims to support the participants in developing an active HEPA behaviour as an instrument for measuring and displaying the health-related fitness, one main goal of the HEPA-based research (Oja, 2008). During the execution and the counselling through an instructor or trainer, the current stage of the participant is identified and ways to raise (stage 1-4) or to maintain the stage (at stage 5) are evaluated and recommended.

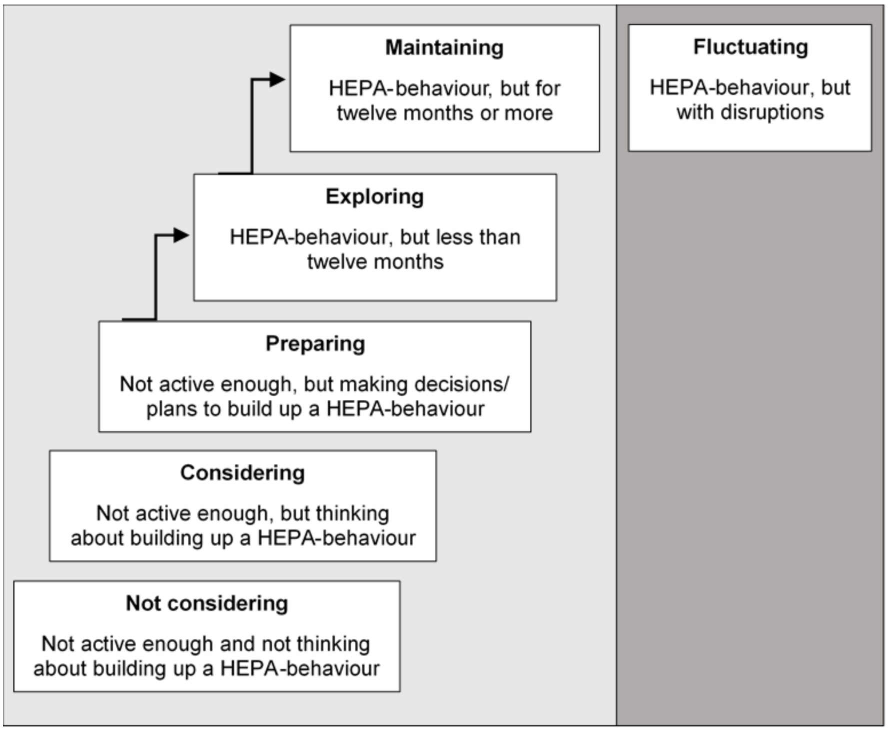


Figure 2-1 The FIT model of HEPA (own illustration after Duan et al., 2013)

2.5. EFB as a diagnostic instrument for the HEPA concept

The European Fitness Badge focusses on "health-related fitness". Based on research it can be stated that the most important components of health-related fitness are cardiorespiratory fitness (endurance), muscular fitness (strength), coordination and flexibility (Bös & Mechling, 1985; Caspersen et al., 1985; Oja, 1991; Samitz & Baron, 2002; Suni et al., 1998). Often other components, especially "body composition" and "posture", are added to this health-related understanding of fitness (ibid.).

Many approaches differentiate basic "motor abilities" as components of "motor fitness", describing a general physical capacity and mostly used in connection to fitness tests. The applied systematisation (cf. Figure 2-2) (Bös, 1987; Bös et al., 2001, 2009; Lämmle et al., 2010) structures the motor abilities into conditioning abilities and coordinative abilities. Conditioning abilities include endurance and strength, whereas speed is partly conditional and coordinative. Coordination under precise conditions and coordination under time pressure are part of the coordinative abilities as well. These abilities are structured into duration and intensity of the physical strain in ten subfields not pointed out in detail in this context. In this understanding, flexibility applies as passive system of energy transfer and is nearly independent of the motor abilities.

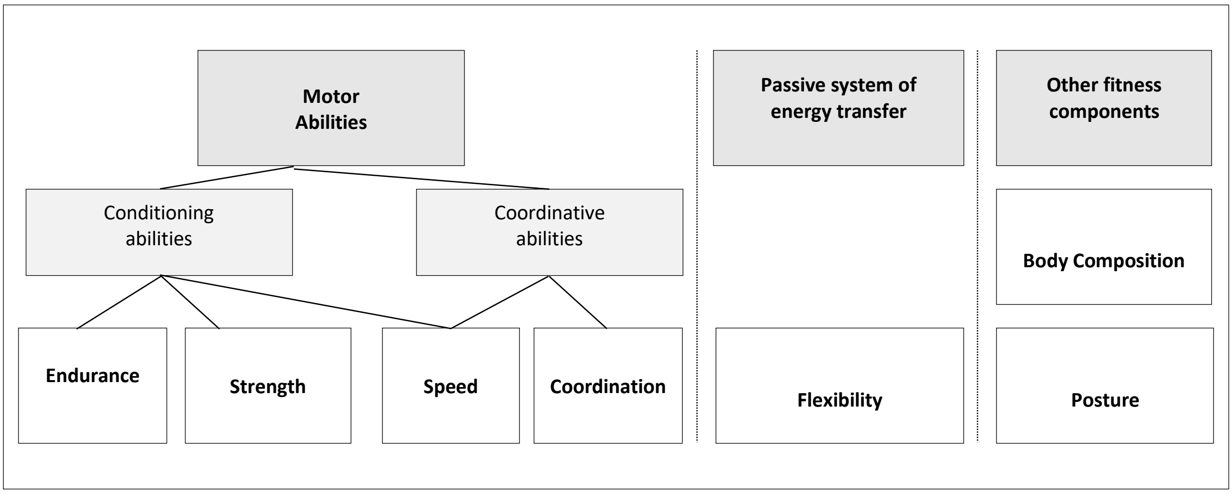


Figure 2-2 Differentiation of motor abilities (own illustration after Bös, 1987; Bös et al., 2001; Bös et al., 2009; Lämmle et al., 2010))

Besides the ability structure, the strained muscle groups and the type of exercise of the performed test items, the following aspects need to be considered for constructing a fitness test (Bös et al., 2009):

- Muscle groups can be differentiated in the whole body: trunk, up-per and lower limbs.
- The differentiation among the structure of exercise is defined as activity with or without change of place (locomotion movement) or as activity with subfield movement.

For a simple taxonomy of test items, a two-dimensional classification including the ability and exercise structure is used. This taxonomy is displayed at Table 2-2. In the interest of health orientation (Suni et al., 1996), speed is neglected due to involvement of it – in particular action speed – in both dimensions, strength and coordination. (Ibid.)

Table 2-2 Taxonomy of test items structured according to ability and exercise structure (own illustration after Bös et al., 2009)

Structure of exercise		**Motor performance abilities**			**Passive system of energy transmission**
		Endurance	**Strength**	**Coordination**	**Flexibility**
Locomotion movements	Walking, running, jumping				
Limb movements	Upper extremities, trunk				

This structure serves as the basis for the development of the EFB test profiles. The project group developed two test profiles, considering the HEPA stages and the taxonomy of test items. With two different test profiles, sedentary people (HEPA stages 2 and 3) and sufficient active people (HEPA stages 4 and 5) are addressed.

Test profile 1 (cf. chapter 2.5.1) is function-oriented (e.g. standing up with one leg, balancing on one leg). The test items are evaluated in three categories (1-3 points). Test profile 2 (cf. chapter 2.5.2) is performance-oriented (e.g. number of performed push-up in 40 seconds). The test items are evaluated quantitatively through age- and gender-specific reference values in five categories according to percentiles.

Other components, which are important for a global counselling, like activity, body composition and posture (cf. chapter 2.5.3) are also part of the European Fitness Badge, but not part of the certificate.

2.5.1. Content of the EFB: Test profile 1

Test profile 1 is designed for testing a basic fitness using test items oriented towards simple daily life functions.

Table 2-3 presents the test items and the additional measurements. As stated before, these additional measurements serve for a broad impression of the fitness status of the participants but not for awarding the level.

Table 2-3 Overview of test items and additional measurements of TP1

Test items of TP1				**Additional measurements**
110 Endurance	120 Strength	130 Coordination	140 Flexibility	
111 Step test 112 N-Ex	121 Plank test 122 Stand-up 123 Push-up	131 Balance 132 Jumpjack	141 Sit&reach	150 Body composition 160 Posture Activity questionnaire

All test items of TP1 are displayed at Table 2-4[1]. First, it is recommended to conduct the step test in the endurance part. The N-Ex acts as a compromise if the required material is not available. In the motor dimension of strength, two out of three test items must be performed. There is a choice between two test items for the upper extremities and one test item for the lower extremities. The last activity is called "Standing up with one leg" and due to occurring questions regarding the height of the chair and the wording of the instruction, a feasibility study was conducted by colleagues of the biomechanical section (Steingrebe et al., 2018). Steingrebe and colleagues stated a good feasibility and no extraordinary strains regarding the knee for this test for test persons aged 50 to 60.

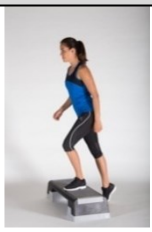
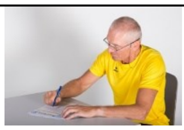
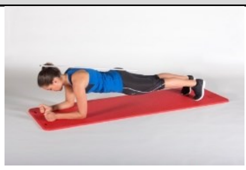
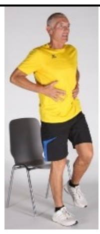
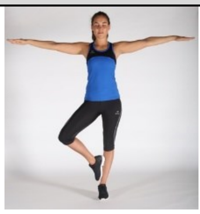
In the coordination part, the test person needs to perform the balancing on one leg test (131) and the jumping jack test (132). The sixth test is the sit & reach test (141) in the category flexibility.

The participants of this test profile are mostly classified at stages 2 or 3 of the HEPA stage model. These adults are not used to strenuous physical activities. Following, there is a higher probability to be overweight or even obese, they are exposed to other risk factors such as high blood pressure, low self-esteem and the barriers to start a regular physical activity are high. Potential settings to execute TP1 are for example, open days or promotional events at fitness or sports clubs. According to the target

[1] For a more detailed description and the evaluation of each test item, please see the handbook for instructors (Bös et al., 2017).

group and setting, the scoring and organisation should be as simple as possible. Therefore, the scoring is equal for every tested person (except gender-specific differentiation at the sit & reach test) and well understandable for each participant. Being successful in this TP and reaching Level 1 certifies a basic fitness and to be able to participate on basic sports courses.

Table 2-4 Short descriptions of the test items of TP1 (Pictures by Qingwei Chen)

ENDURANCE		
Step test		Stand close to the step bench, step up with one leg after the other, step down with one leg after the other: up-up-down-down.
N-Ex test		An activity-questionnaire needs to be answered honestly.
STRENGTH		
Plank test		The challenging position, with the body's weight borne on forearms, elbows, and toes need to be hold up to 30 seconds.
Standing up with one leg		Stand up from a chair using after another both legs, then one leg and then the other leg and keep the balance.
Push-up test		Push-ups with knees steady on the floor (five) and push-ups with straight legs (five) should be performed in this test.
COORDINATION		
Balancing on one leg		Balance on one preferred leg with open and closed eyes for 15 seconds each.

Jumping Jack		Perform ten jumping jacks fluently without interruptions.
FLEXIBILITY		
Sit and reach		Sit on the floor with legs stretched out straight ahead and try to reach forward along the measuring line as far as possible.

2.5.2. Content of the EFB: Test profile 2

Test profile 2, as counterpart to TP1, is designed for testing an average and over-average fitness with test items oriented towards challenging motor performance tests. Table 2-5 displays the test items and the additional measurements.

Table 2-5 Overview of test items and additional measurements of TP2

Test items of TP2				**Additional measurements**
210 Endurance	220 Strength	230 Coordination	240 Flexibility	
211 Step test 212 Walking	221 Plank test 222 Jump 223 Push-up	231 Flamingo 232 Walkback	241 Sit&reach	250 Body composition 260 Posture Activity questionnaire

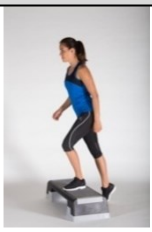
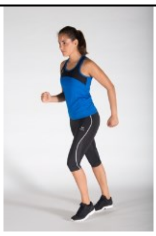
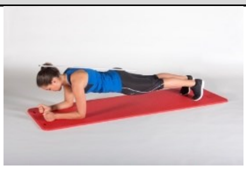
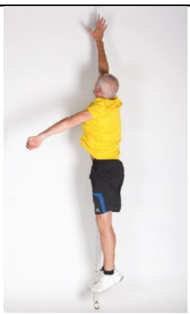
All test items of TP2 are represented at Table 2-6[2]. First choice of the endurance part is the step test (211), which monitors the cardiorespiratory endurance. Second choice is the walking test, which contains the same, but is linked to a higher organisational effort due to a walking course of 2 km. Concerning strength, two out of three tests need to be performed. The test person can choose between the plank test (221), the jump and reach test (222) and the push-up test (223). In the coordination part, both tests need to be performed: the flamingo balance test (231) containing the static postural control and the walking back test (232) containing the dynamic balance. The flexibility will be monitored through the sit & reach test (241).

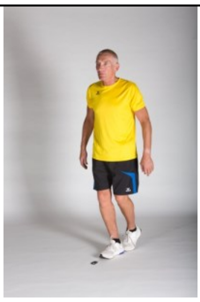
Advanced fitness corresponds to an average fitness level of the population (percentile rank 40 - 60) of the same age and sex. Approved fitness means, the fitness level is better than the average of the population (better than percentile rank 60) of the same age and sex. The test person is among the fittest 40% of the corresponding age group. Regarding the HEPA concept, participants of this test profile are classified in stages 4 or 5. The scoring in TP2 accords to the age and the sex of the test person, which means that the result of every single test person will be compared with the results of the reference group of the general population. With the help of existing norms and executed studies in the last years (Aadahl et al., 2013; Bös et al., 2012; Strand et al., 2014), the scoring of TP2 could be

[2] For a more detailed description and the evaluation of each test item, please see the handbook for instructors (Bös et al., 2017).

determined. In addition, the norms will be renewed after a certain period to fulfil a modern and current badge. Depending on the overall score, participants can achieve Level 2 Advanced or Level 3 Approved. The counselling of this test profile focusses on improving or stabilizing the activity level and increasing the health-related fitness of the participant.

Table 2-6 Short descriptions of the test items of TP2 (Pictures by Qingwei Chen)

ENDURANCE		
Step test		Stand close to the step bench, step up with one leg after the other, step down with one leg after the other: up-up-down-down up to 6 minutes.
2km Walking test		Walk a flat way of 2 km with the walking technique as fast as possible.
STRENGTH		
Plank test		The challenging position, with the body's weight borne on forearms, elbows, and toes need to be hold as long as possible.
Jump and reach		Measuring the vertical reach when standing sideways to the wall. Jump as high as possible while touching the wall with the hand for jumping reach. Measuring the difference between vertical and jumping reach.
Push-up test		Lie in a prone position on the floor. The hands are touching over the buttock. Lift your whole body up in a push-up position. One hand touches the other and goes back in the push-up position. Lower the whole body straight to the floor and put your hands over the buttock together. Do as much push-ups as possible in 40 seconds.
COORDINATION		

Flamingo balance		Balance with the preferred leg on a balance beam for one minute. The other leg is stretched sideways and shouldn´t touch the balancing leg. The number of fails (touching the ground or touching the standing leg) are counted.
Walking backwards		Walk a 6 m walking distance backwards as fast as possible. The toes of one foot should touch the heel of the other one.
FLEXIBILITY		
Sit and reach		Sit on the floor with legs stretched out straight ahead and try to reach forward along the measuring line as far as possible.

2.5.3. Content of the EFB: Additional measurements in TP1 and TP2

As a broad instrument for displaying the health-oriented fitness, the EFB includes two indices for body composition and one test for measuring the posture. A body shape index (ABSI) and the body mass index (BMI), the Posture test and the activity questionnaire are not part of the level evaluation but show additional health aspects that are considered during the counsel-ling.

The ABSI is recommended as the first choice and as an alternative for the well-known BMI. Krakauer & Krakauer (2012) developed the ABSI for having a well-developed index regarding the body composition. It includes the weight and height measurement as well as the measurement of the waist circumference. If participants do not want to be measured at the waist, the BMI as a common alternative will be calculated.

During the posture test, the test instructor observes the participants during an upright standing position. The instructor compares the posture with five typical posture characteristics.

The activity questionnaire serves for two purposes: First, the results of the questionnaire operate as statistical values, and second, in TP1 this value can be used as N-Ex test in the endurance dimension.

Overall, the participant gains a broad impression of the body and posture status, on top of the Level evaluation. These additional measurements are important for the individual counselling (cf. chapter 2.5.4), which is following the execution of the EFB.

2.5.4. Content of the EFB Process: Counselling process

Immediately after the fitness test is performed, counselling is conducted for promoting HEPA behaviour. The counselling is based on the test results calculated by the EFB-online data platform. This platform was specially developed for the evaluation of the EFB, including user-friendly input of the data and immediate calculation, evaluation and printing or mailing option of the certificate and the detailed feedback.

Due to the simple and fast output of the online data platform, the counselling can start a few minutes after the EFB execution. The aim of counselling is the sustainable usage of the results regarding the stages of the HEPA concept. The instructor aims to encourage the participant reaching the next stage (stages 2-4) or maintaining the stage (stage 5). A dialogue which includes creating a realistic plan and realistic short- and long-term aims is the heart of counselling. In the end the participant has a certain and clear action plan.

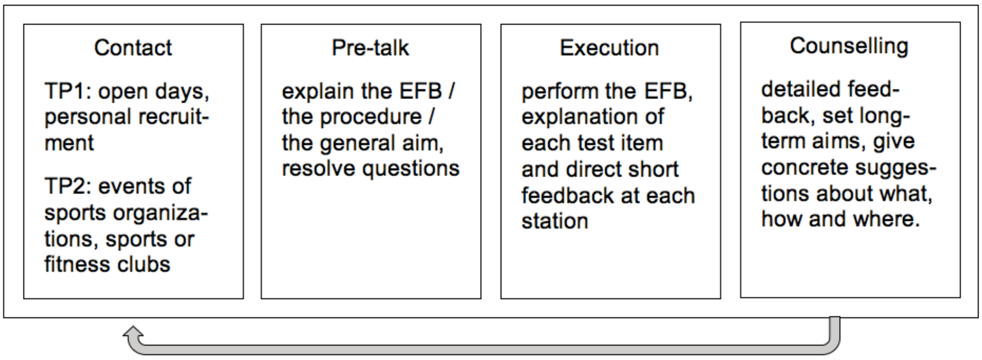


Figure 2-3 Process of the EFB

Taking Figure 2-3 into account, the process of this counselling and the whole EFB is visible. The EFB aims to motivate people towards a HEPA behaviour. With the counselling in the end participants can develop an active behaviour and with that new being active lifestyle they qualify again after a certain time to participate at the EFB and therefore control and overview their health-related fitness.

2.6. Evaluation during the EFB development

During the development phase of the EFB between 2015 and 2017, studies in Germany, Belgium and Denmark were executed for proving single test items, the acceptance, feasibility, psychometric properties and the general concept of the EFB.

For proving the acceptance, feasibility and psychometric properties of both test profiles a study was conducted between March and April 2016 by the KIT team. In a small town in South Germany, 86 test persons executed the EFB with the help of six test instructors. (TP1: N = 22, m, f; age = 24 - 76 years; TP2: N = 64, m, f, age = 26 - 67 years)[3].

During two weeks, test persons performed the EFB twice with one week in between. At the retest during the second test week, 19 participants at TP1 and 60 participants at TP2 took part.

Test persons and test instructors rated the feasibility and the acceptance of the test items via a survey of 14 items. The survey was developed in English and in German due to the different origins of the test instructors (Germany and Belgium) and to ensure comparability with the international studies. Attempts were made to get a very short and understandable survey. Therefore, the single questions were formulated as statements which can be answered in the five-tier scale (Porst, 2009; Schnell et al., 2011) "Strongly agree" (1), "Agree" (2), "Neutral" (3), "Disagree" (4) and "Strongly disagree" (5).

[3] Intensive efforts in reaching a bigger sample of inactive test persons for test-retest studies have not been successful until now. Further research during the second funding period is needed.

2.6.1. Results: Feasibility and acceptance

Altogether, feasibility was rated by test persons and instructors with 1.5 (1.8) at TP1 and 1.4 (0.6) at TP2, the acceptance with 1.5 (1.4) at TP1 and 1.5 (1.2) at TP2 (mean scores). The scores for the single items were rather homogeneous and reached from 1.0 to 2.8 in the different scales.

2.6.2. Results: Psychometric properties of TP1

Objectivity and Reliability

The proof of the psychometric properties of TP1 was limited due to the small sample. Nonetheless, Table 2-7 displays an overview about the results of the test-retest comparison for proving objectivity and reliability. As statistical test values the Chi-square value (Chi²), the Gamma coefficient as an indicator for the correlation and the accordance of evaluation, were calculated. In certain cases, these values could not be calculated due to missing variance of the results (not available = n.a.). Because of the small sample of N = 18 a gender-specific consideration was skipped. The last column illustrates the evaluation made either through the Chi2 and Gamma calculation or through the presentation of the accordance. For proving the accordance of the test results, 3x3 contingency tables of the scoring points from T1 and T2 were calculated.

*Table 2-7 Overview about the results of the contingency tables for proving the test-retest reliability (N = 18) (significance: ** = p ≤ 0.01, *** = p ≤ 0.001; reliability: "+" = good reliability, "0" = sufficient reliability, "-" = non-sufficient reliability)*

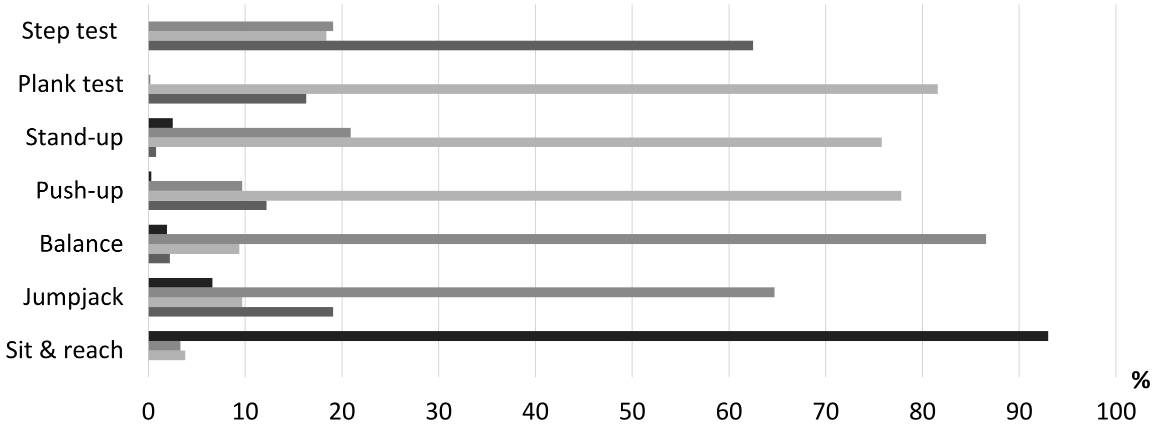
Test item	Chi²	Gamma	Accordance (of T1 and T2)	Reliability interpretation
Step test	n.a.	n.a.	89%	+
N-Ex	36.00***	1.0	100%	++
Plank test	n.a.	n.a.	100%	++
Stand up	18.00***	1.0	94%	++
Push-up	10.88**	1.0	72%	+
Balance	1.46	0.1	67%	-
Jumping jack	n.a.	n.a.	89%	+
Sit&reach	14.16**	0.9	78%	+

Besides the balance test, all test items included into the level score have a good or very good reliability. Due to these results of the balance test and the experiences during the test performance (high difficulties during performing this exercise), the test description was modified. The instruction of keeping the arms bent with the hands on the hips changed into a free use of the arms for balancing.

Content validity

An expert rating was executed for proving the content validity. The consulted test experts (N = 16) were either part of the international project group or employees of the Institute of Sport and Sport Sciences at the KIT. Based on their knowledge and with the help of the test descriptions, the experts had to evaluate all test items according to the motor abilities endurance, strength, coordination and flexibility. Therefore, they used percentages. For example, they were asked to evaluate the jump and reach test and according to their opinion they may evaluate like 0% endurance, 80% strength, 10%

coordination and 10% flexibility. Out of the received percentages, a general mean value for each motor ability and the appropriate test item was calculated. Figure 2-4 gives an overview about the expert opinions of the TP1 test items.



	Sit & reach	Jumpjack	Balance	Push-up	Stand-up	Plank test	Step test
Flexibility	93	6,6	1,9	0,3	2,5	0	0
Coordination	3,3	64,7	86,6	9,7	20,9	0,2	19,1
Strength	3,8	9,7	9,4	77,8	75,8	81,6	18,4
Endurance	0	19,1	2,2	12,2	0,8	16,3	62,5

Figure 2-4 Mean values of the motor dimensions the experts rated the test items with (in %)

Altogether all test items have been verified through the test experts. The assigned motor dimension corresponds to the motor dimension the test experts rated, and the content validity is given.

2.6.3. Results: Psychometric properties of TP2

Objectivity and reliability

The objectivity of application and the reliability was proved through a test-retest analysis with an alternating investigator. The test-retest reliability depends on the two following aspects:

1. Stability of the ranking order
2. Comparability of the mean values

For proving these two aspects, comparisons of the mean values and correlations were calculated with a paired t-test. As statistical test values the significance p and the reliability r were calculated. These results are displayed at Table 2-8. The stability of ranking order is displayed through r whereas the comparability of mean values is especially visible through the difference in the mean value (Diff. x̄ in %).

*Table 2-8 Overview about the results of the calculated paired t-tests of TP2 (** = p ≤ 0.01, *** = p ≤ 0.001)*

Test item (v*alue)*	**T1 x̄(s)**	**T2 x̄(s)**	**N**	**Diff.**	**Diff. x̄ (%)**	**t**	**p**	**r**
Step test *(Vo_2max)*	42.1 (8.3)	43.8 (9.7)	54	1.7	4	1.8	-	0.71
Plank test *(sec)*	162.4 (86.0)	166.8 (84.1)	56	4.4	3	0.8	-	0.88
Jump *(cm)*	29.2 (6.4)	31.7 (10.0)	56	2.6	8	3.5	**	0.86
Push-up *(n°)*	13.5 (4.1)	15.8 (4.0)	52	2.3	15	6.5	***	0.79
Flamingo *(n° of fails)*	2.5 (3.7)	2.2 (2.9)	54	0.3	14	0.9	-	0.70
Walkback *(sec)*	11.9 (3.1)	10.9 (2.9)	55	1.0	9	3.3	**	0.75
Sit&reach *(cm)*	6.7 (9.3)	7.1 (9.8)	56	0.4	6	0.7	-	0.93

As Table 2-8 is showing, the results of the whole sample display sufficient ranking stabilities (> 0.6) at all test items. Stability of the mean values is missing (> 10%) at the push-up test and the flamingo test. Training effects may influence the results at the push-up test, or the high coordinative part in this test may have a bigger influence than expected. It is possible that the test persons had a better strategy for concentrating at the second test day or that they have been more concentrated through knowing the whole test situation. In general, all test items were well evaluated in objectivity and reliability.

Content validity

The content validity in TP2 was proved through an expert rating. Table 2-9 gives an overview about the expert opinions concerning the test items of TP2. The main abilities presented are marked in bold letters.

Table 2-9 Overview about the mean values of the expert rating in %, TP2 (N = 16)

Test item	Endurance x̄(s)	Strength x̄(s)	Coordination x̄(s)	Flexibility x̄(s)
Step test	63.8 (13.0)	18.8 (8.7)	17.5 (8.2)	0 (0)
Walking	89.2 (10.7)	3.7 (6.1)	6.1 (5.3)	1.0 (2.8)
Plank test	20.9 (21.0)	76.9 (20.2)	2.2 (5.5)	0 (0)
Jump	0.9 (2.7)	76.6 (10.3)	17.2 (8.4)	5.3 (5.3)
Push-up	15.3 (10.9)	70.6 (14.2)	12.8 (9.8)	1.3 (2.9)
Flamingo	2.2 (5.5)	14.4 (19.7)	72.8 (34.2)	10.6 (27.2)
Walkback	1.3 (3.4)	2.5 (5.5)	93.3 (7.4)	2.9 (4.4)
Sit&reach	0 (0)	3.8 (5.9)	3.3 (5.7)	93.0 (7.6)

The test experts do not agree completely, especially in the plank test and the flamingo test, which both show high standard deviations. The high standard deviations in coordination and flexibility might occur because some experts define the flamingo test as a flexibility test, whereas others define it as coordination test.

Generally, all test items have been verified through the test experts. The assigned motor dimension corresponds to the motor dimension the test experts rated; the content validity is given.

For further results, please see the work of Klemm and colleagues (2017).

2.7. Discussion and Perspective

According to the above-described concept of the EFB and the named results of first studies, the European Fitness Badge can be described as a satisfying instrument for displaying the fitness status of a person and other components like body composition and posture for a health-related fitness. Future studies need to confirm these first findings.

The results of evaluations are showing positive tendencies in the aspects of psychometric properties, acceptance and feasibility by all involved groups like test persons, test instructors and test experts. These results need to be handled carefully due to the small sample and the wide age range. Overall, more studies, which are planned during the new funding period, need to be conducted for confirming these tendencies.

Currently the execution of the EFB is possible in the following countries: Austria, Belgium, Denmark, Germany, Bulgaria, Slovenia and Spain. These countries have access to the online data platform and one organisation is responsible for trainer seminars and the detailed dissemination in their country.

Effectively in September 2017, after the introduction of the EFB in June the same year, around 800 people executed the EFB, most of them performed TP2. Furthermore, in Germany, Austria, Denmark and Spain the trainer seminars have taken place or will take place soon for having even more multipliers to spread the EFB. Today around 80 multipliers in Europe are educated. The execution took place especially at big events like the Turnfest in Germany, the Landstaevne in Denmark or at different events during the Move Week. At the Turnfest in Berlin, 512 persons took part at test profile 2. The event was without registration; the test persons could just walk by and take part. 364 female and 148 male persons executed the test. The average age was 42.27 years. The last big wave of Europe-wide execution occurred in the last week of September during the European Week of Sports, in which European countries tried to get as much sports events as possible in their country and achieve the major number of participating persons and offered events in comparison to other countries. At a special event in 2017, organised in Karlsruhe, in cooperation with a newspaper and an insurance company, both test profiles were offered for the public. Only one person executed TP1, while the other 131 participants executed TP2.

The handling of test profile 1 is one upcoming task for the second phase of the EFB project, because the target group of this profile needs to be motivated directly. Ideas for improving this situation are for example, to visit these groups at their workplace or at events in the city. The "Verein für Sport und Gesundheitsförderung (VSG)" at the Institute of Sport and Sport Science (Karlsruhe Institute of Technology) in Germany is the responsible partner for such scientific questions and organises the data evaluation and handling in cooperation with the second scientific partner, the Artevelde University College from Ghent, Belgium.

The next EU-funded period will start in January 2018 terminating in December 2019. In this period, the project group will focus on the further dissemination and evaluation. This time, the scientific part of the project plans the necessary Europe-wide studies at both test profiles for evaluating the acceptance by test instructors and test persons as well as generating new norms for the test items and answering questions like the one concerning test profile 1.

3. Manuscript 2: Health-related fitness in adults from eight European countries – An analysis based on data from the European Fitness Badge

Published as Klemm, K., Krell-Roesch, J., De Clerck, I.L., Brehm, W. and Boes, K. (2021). Health-Related Fitness in Adults From Eight European Countries—An Analysis Based on Data From the European Fitness Badge. Front. Physiol. 11:615237. doi: 10.3389/fphys.2020.615237

3.1. Abstract

Background: There are conflicting reports about the fitness status of European adults, partly due to the lack of a standardized fitness test battery used across Europe. The European Fitness Badge (EFB) was developed in 2017 as an online-based tool to assess the health-related fitness of persons aged ≥ 18 years residing in European countries. We examined the demographic characteristics and fitness status of persons who completed the EFB between June 2017 and May 2019.

Methods: We conducted a multinational study in eight European countries. Participants completed the EFB which includes eleven validated motor tests to measure endurance, strength, coordination and flexibility performance, under the supervision of an EFB instructor in different settings (e.g. sports club sessions, public events). Two different test batteries (test profiles, TP) are available to distinguish between less active (TP1) and active individuals (TP2). We calculated descriptive statistics and conducted analyses of variance to examine sample characteristics and a potential impact of sex, age, body mass index (BMI), physical activity and posture on fitness as assessed by the EFB.

Results: The sample included 6,019 adults (68.7% females; mean age 52.7 years; age range 18-89 years). Participants who completed TP1 were older (TP1: 61.4 years; TP2: 44.2 years; $p = 0.00$), reported a lower level of physical activity (TP1: 3.8; TP2: 4.0; $p = 0.00$), had a higher BMI (TP1: 25.7; TP2: 24.3; $p = 0.00$) and a higher frequency of postural abnormalities (TP1: 43%; TP2: 33%; $p = 0.00$) than TP2 participants. Among 3,034 participants who completed TP2, males had higher performance in endurance, strength and overall fitness, whereas females performed better in coordination and flexibility tests. In addition, younger age, lower BMI and higher level of physical activity engagement was associated with better EFB test performance.

Conclusions: The EFB can be used to assess the health-related fitness status of individuals aged ≥ 18 years. Our results show that TP1 and TP2 were completed by persons from the respective target groups (i.e. less active vs. active), and also confirm findings from previous studies on potential determinants of fitness such as sex or age.

3.2. Introduction

Physical inactivity and sedentary behavior are among the main risk factors for various non-communicable diseases such as cardiovascular diseases or metabolic syndrome (Katzmarzyk, 2010; Lee et al., 2012; Thorp et al., 2011; Wen et al., 2011). These diseases are associated with high economic burden as they often lead to loss of work force or early retirement (Ding et al., 2016). Physical inactivity and sedentary behavior are highly prevalent in Europe, i.e., 46% of Europeans never engage in physical exercise or sport activities and this number has increased over the last ten years (European Commission, 2018). One way to potentially impact people's health-related behavior and motivate them to maintain or adopt an active lifestyle are individually tailored programs such as cardio or aerobic exercise programs. However, a prerequisite for a successful exercise program is a valid diagnosis of the current fitness status of a person (Godino et al., 2014).

We and others have reported that physical activity engagement is associated with fitness levels (Bouchard et al., 2012; Sandvik et al., 1993; Tittlbach et al., 2017). For example, in one of our previous studies based on EFB data, we reported that a higher physical activity level correlates with a higher fitness level. In addition, based on extreme value comparison, we showed that individuals with low fitness level had higher probability of being physically inactive than persons with high fitness level (Klemm et al., 2020).

Various fitness tests are used in Europe such as the German Sports Badge (Deutscher Olympischer Sportbund (DOSB), o. J.), the Austrian Sport and Gymnastic Badge (Bundesministerium für Kunst, Kultur, öffentlichen Dienst und Sport, o. J.) or the Eurofit test for adults (Oja & Tuxworth, 1995). However, studies on the fitness of adults residing in Europe mostly focused on cardiorespiratory fitness and its relationship to NCDs (Ekblom-Bak et al., 2010; Hamer & Steptoe, 2009; Zaccardi et al., 2015) or mortality (Ekblom-Bak et al., 2019; Jensen et al., 2017; Laukkanen et al., 2001; Robsahm et al., 2016). In the last twenty years, only few national studies examined the association between fitness status and potential determinants such as age or sex based on data from scientifically proven fitness tests in Europe (Crump et al., 2016; Ekblom et al., 2007). In addition, the majority was also focused on cardiorespiratory fitness. This is in line with studies from the US, where more research regarding physical and health-related fitness has been carried out in the last decade (Blair et al., 1995; Hamer & Steptoe, 2009; Lee et al., 1999; Lee et al., 2010). To the knowledge of the authors, there is currently no fitness test available that comprises all health-relevant fitness dimensions, i.e., endurance, strength, flexibility and coordination (Caspersen et al., 1985) and that can be completed by and is accessible to a broad population of adults residing in different European countries. Additionally, a recent systematic review on the decline of cardiorespiratory fitness worldwide called for a multinational surveillance system to monitor health and fitness trends (Lamoureux et al., 2019).

Furthermore, research has shown that fitness tests are predominantly completed by individuals who are physically active on a regular basis and have a good fitness status (Barreto et al., 2013; Finger et al., 2013); thereby highlighting the need of a test battery that is also appealing to individuals who are physically inactive or have a low fitness status.

To address these paucities, the European Fitness Badge (EFB; www.fitness-badge.eu) was developed between 2015 and 2017 and published in 2017. The EFB is a novel and innovative tool for the following reasons: 1) It is based on the internationally known Health-Enhancing Physical Activity (HEPA) concept (Martin et al., 2006); 2) it addresses the whole adult European population regardless of an individual's physical activity level. To this end, the EFB it consists of two different test profiles, i.e., one that is suitable for persons who do not engage in physical activity on a regular basis or who are older (TP1), and one for younger persons or those who regularly engage in physical activity (TP2) (Klemm et al., 2017); 3) it includes eleven objective motor tests structured based on the health-oriented fitness dimensions endurance, strength, coordination and flexibility plus additional measurements for body composition, posture and stability (Bös et al., 2017); 4) handling and storage of data is fully automized through the EFB online data platform; 5) data are collected, i.e. the test is administered and evaluated by licensed and educated EFB instructors; 6) it was designed for exercise instructors who administer the test participants of their exercise training groups, during public events or in fitness clubs or companies; and 7) a first evaluation with regard to acceptance, feasibility and psychometric properties of the EFB was carried out in 2016 prior to the publication of the EFB (Klemm et al., 2017).

With regard to these strengths of the EFB, this current study has three specific aims: 1) To examine the dissemination of the EFB by summarizing the demographic characteristics (i.e., age, sex, level of physical activity, BMI and posture) of persons who completed the EFB within the first two years after its inception and as stratified by country of residence. 2) To examine whether the EFB reaches the respective target groups (i.e., both less active and active persons) by calculating differences in age, level of physical activity, BMI and posture abnormalities between participants who completed TP1 (for less active persons) versus TP2 (for active persons; content-related validity). 3) To examine whether the data collected by the EFB are comparable to what has been reported in literature with regard to a potential impact of sex, age, BMI, and physical activity on fitness status among participants who completed TP2.

Based on results from preliminary studies in various European countries (Eriksen et al., 2016; Finger et al., 2013; Klemm et al., 2017) and based on the expertise of involved investigators and results from previous physical activity programs (Bauer et al., 2018; Pahmeier et al., 2012), we hypothesized that 1) participants who completed the EFB would reside in various European countries and would have a moderate to high level of physical activity; 2) participants who completed TP1 would be older, less physically active and had a higher BMI than participants who completed TP2; and that 3) there would be significant effect of age, sex, BMI and physical activity engagement on fitness performance among participants who completed TP2.

3.3. Methods

Study setting

The EFB is funded by the European Union (EU) (2015 – 2019). Sport and Gymnastic organizations as well as scientific partners from ten institutions across eight European countries were involved in the development of the EFB (Austria, Sportunion; Belgium, Artevelde University of Applied Sciences; Bulgaria, BG Be Active; Denmark, Danish Gymnastic and Sports Federation; Germany, German Gymnastic Federation, Karlsruhe Institute of Technology; Slovenia, Sports Union Slovenia; Spain, UBAE; Europe wide, International Sports and Culture Association). Throughout the entire year, the EFB can be accessed by all interested organizations in Europe. Data are gathered online by these partner institutions. Organizations in participating countries offer completion of the EFB in different settings such as during sports club training sessions, community activities or public events such as the European week of sports, according to their abilities and outreach. As the overarching goal is to make the EFB available to any adult residing in Europe, the only exclusion criteria of the EFB are age < 18 years and one or more items on the physical activity readiness questionnaire (PAR-Q) that were answered with "yes" (Bös et al., 2017). The EFB is administered to participants by licensed instructors who successfully completed a one-day EFB instructor workshop. After completion of the EFB, each participant receives an individual certificate and additional feedback of seven pages on how to improve his/her fitness by those trained instructors. Collected data is saved on an online data platform accessible by all EFB instructors via an individualized access code. Data can be exported to Excel and SPSS through an anonymized output. The study procedures were approved by the ethics committee of the Karlsruhe Institute of Technology (Tittlbach et al., 2017). Participation in the EFB is voluntary and all participants provided written informed consent.

Measurements

A detailed description of the test items of the EFB has been published elsewhere (Bös et al., 2017; Klemm et al., 2017). Briefly, the EFB has two test profiles and participants are asked to choose one profile based on their level of physical activity. The level of physical activity is determined based on the N-Ex questionnaire that all participants are required to complete prior to the testing. Both test profiles consist of motor performance tests to assess endurance, strength, coordination and flexibility. Additional measurements to assess activity, posture, body height, body weight and waist circumference are included in the EFB as well (please refer to Figure 3-1). Before carrying out the EFB, each participant is required to complete the physical activity readiness questionnaire (PAR-Q).

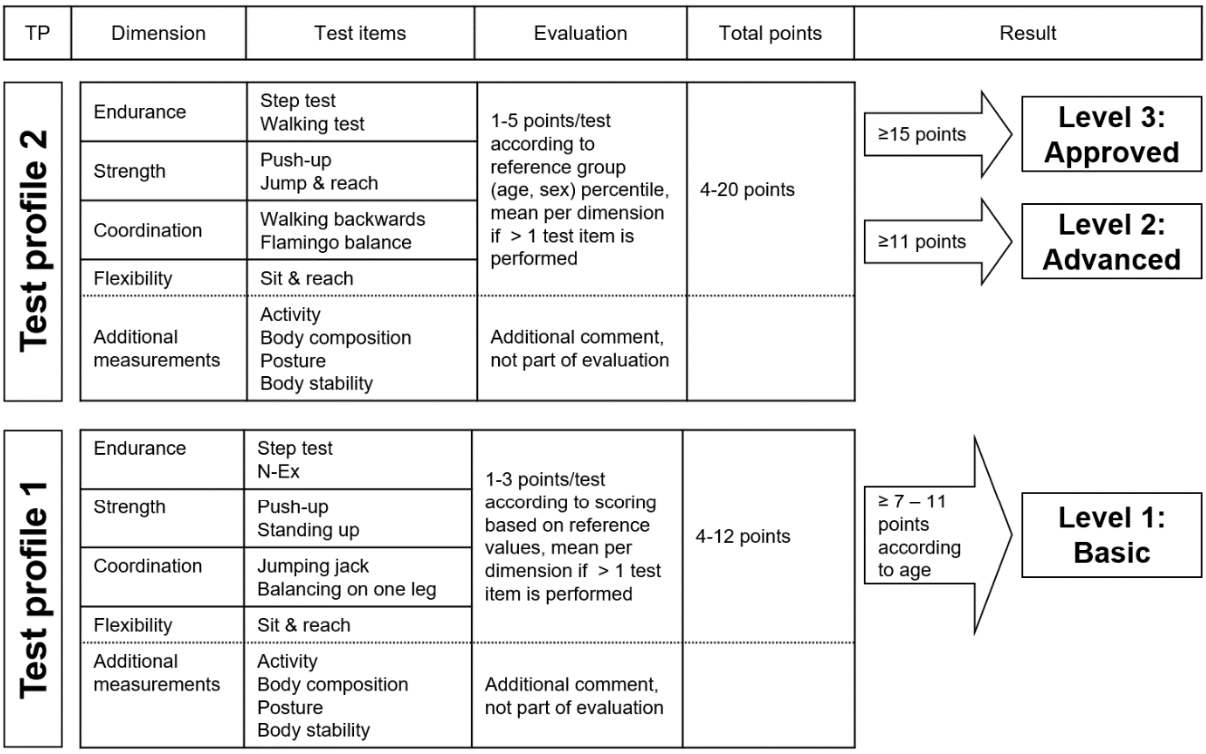


Figure 3-1 Overview of the EFB test profiles and the according evaluation

Test profile 1 (TP1) was designed for less active or older individuals and mainly assesses functional performance (e.g. standing up with one leg). Scores for each test range from 1-3 points according to the performance and based on validated reference values (Bös et al., 2017). TP1 was designed in a way that between 60 and 80% of test participants should achieve the highest score of 3 points in every test item, regardless of age and sex (exception is the sit & reach test, see (Klemm et al., 2017) for details). This decision for the relatively high rates of achievement of the highest score was based on the goal of the EFB developers to motivate people who only have a low level of fitness to be physically active and thereby further improve their fitness.

The scores for each of the items are summed up based on the four dimensions of fitness, i.e. endurance, strength, coordination and flexibility. If more than one test item is performed per dimension, the average value is calculated. In the next step the overall test result including all four dimensions is calculated. This value ranges from 4 points (1 point in each dimension) to 12 points (3 points in each dimension). The interpretation of the total score varies by age group and is based on expert consensus (Bös et al., 2017), i.e. younger people require more points (participants aged ≤ 40 years need ≥ 11 points) than older people (participants aged > 70 years need ≥ 7 points) to reach a “basic” level. If a person does not reach the minimum number of required points, then they receive a participation certificate with feedback information.

Test profile 2 (TP2) addresses physically active people and is considered performance-oriented (e.g., number of fails during balancing on a beam). The test performance is evaluated quantitatively using age- and gender-specific reference values (Bös et al., 2017) in five categories [1-5] according to percentiles. The point values refer to quintiles: 1 point = percentile rank 0-20, 5 points = percentile rank 81-100. As for TP1, results from individual tests are combined based on the motor dimensions. Overall values range from 4 points (1 point per dimension) to 20 points (5 points per dimension). Based on their test performance, participants that complete TP2 receive an "advanced" or "approved" certificate (please refer to figure 1). If a person does not achieve a minimum of 11 points for the "advanced" level, then the person receives a participation certificate with feedback information.

To measure physical activity, the N-Ex test is included in the EFB (Jurca et al., 2005). Participants are asked to choose one of five descriptions of usual physical activities during a normal week that best reflects their activity level. The questionnaire distinguishes between "house and family care" [1], "low level activities like stair climbing" [2], "20-60 minutes physical activity" [3], "60-180 minutes physical activity" [4] and "more than 180 minutes physical activity" [5]. Physical activity assessed by to the N-Ex reflects physical activities carried out with at least moderate intensity, i.e. with substantial increases in breathing and heart rate. When answering 1 or 2, the participants receive the recommendation of completing TP1, when answering 3, 4 or 5, it is recommended they undergo TP2.

The posture test is an observation test, i.e., the EFB instructor observes the test person during natural standing and determines the quality of posture. For the purpose of this research, we used the following two results from the posture test: no abnormality [1] and at least one abnormality [2], such as a forward head bending or a hollow lower back.

Furthermore, measurements of body weight and height were taken to calculate the body mass index (BMI), and waist circumference was also assessed.

Statistical analysis

Participant demographics (i.e., age, sex, physical activity, BMI, posture) as stratified by country were analyzed and summarized using means (M) and standard deviation (SD).

In a first step, we calculated two-factorial analyses of variance (ANOVA) to examine whether there was a difference in age, level of physical activity, BMI and posture abnormalities between participants who completed TP1 versus TP2. We calculated main effects of test profile, sex, and the interaction effect (test profile x sex). Results are displayed using M, SD, and interpreted based on F-values and p-values for the main and interaction effects, and effect sizes (eta square, η^2). Given the large sample size it is not sufficient to only consider p-values. Rather, effect sizes may be more meaningful when interpreting the findings.

In a second step, we ran one-factorial ANOVA to examine whether performance in endurance, strength, coordination, flexibility and overall fitness (all z-transformed variables) differed between groups of participants who completed TP2. We created the following groups: sex (males and females), age (18-39 years, 40-59 years, and > 59 years), BMI (normal weight 18.5-24.9, overweight 25.0-27.4, and obese > 27.4), and physical activity level (< 60 minutes per week, 60-180 minutes per week, and > 180 minutes per week). Given the z-transformation of fitness variables, the mean for all groups is 100 (SD = 10). This allows for a comparison of performance across fitness variables and between groups. This calculation could only be done in TP2 participants due to the availability of quantitative fitness results (i.e., continuous fitness variables) in this TP.

The significance level for all analyses was set at $p = 0.05$. Partial eta square (η^2) was categorized after Cohen (36) to low ($\eta^2 \geq 0.01$), medium ($\eta^2 \geq 0.06$) or high ($\eta^2 \geq 0.14$). Statistical analysis was performed using IBM SPSS Version 24.

3.4. Results

Demographic breakdown of EFB participants (aim 1)

Table 1 provides an overview of demographic and other pertinent characteristics of participants stratified by country and EFB test profile. 6,019 adults (68.7% females) aged between 18 and 89 years completed the EFB between June 1, 2017 and May 31, 2019. The mean (SD) age was 52.7 (16.7) years. The largest age group were those aged 60 to 69 years (27.4%), followed by participants aged 50-59 years (17.3%), aged ≥70 (15.9%), 40-49 (15.3%), 18-29 (13.1%) and 30-39 (10.9%). 73.6% of all participants reported being physically active for at least one hour per week, 14.7% reported between 20 and 60 minutes of physical activity per week and 11.7% reported no physical activity engagement in a regular week. Participants were from eight different countries, with 41% being from Denmark, 36.9% from Germany, 11.1% from Slovenia, 4.5% from Spain, 3.5% from Belgium and 3.1% from Austria. However, due to low numbers of participants from Bulgaria (N = 1) and Czech Republic (N = 2), we did not include the results from these participants in further analyses (Table 3-1).

Table 3-1 Characteristics of study participants by country and EFB test profile

	EFB test profile 1						**EFB test profile 2**					
Country (N)	**N**	**Sex (% female)**	**Age (M, SD)**	**Activity (M, SD)**	**BMI (M, SD)**	**Posture (% no abn.)**	**N**	**Sex (% female)**	**Age (M, SD)**	**Activity (M, SD)**	**BMI (M, SD)**	**Posture (% no abn.)**
AUT (186)	67	59.7	53.84, 13.88	3.88, 1.14	24.26, 3.20	72.6	119	58.8	40.33, 11.81	4.10, 0.91	23.65, 3.19	88.9
BEL (211)	18	66.7	41.89, 6.67	3.12, 1.38	24.43, 2.58	46.7	193	71.5	37.72, 8.32	3.25, 1.41	24.36, 3.00	43.5
DEN (2465)	1999	76.9	66.66, 6.92	3.83, 1.11	25.56, 4.33	56.2	466	57.9	44.54, 12.79	3.87, 1.06	25.37, 4.03	54.6
ESP (268)	166	68.7	44.12, 17.32	3.58, 1.52	27.28, 5.25	28.0	102	51.0	37.38, 12.84	4.73, 0.75	24.51, 4.02	53.9
GER (2220)	595	65.7	48.55, 16.18	3.82, 1.14	25.42, 4.26	75.2	1625	64.7	46.30, 16.34	4.21, 0.89	24.01, 3.61	76.4
SVN (666)	140	89.3	66.89, 7.12	4.16, 0.84	27.33, 4.86	22.9	526	63.5	42.03, 14.60	3.81, 1.12	24.49, 3.81	54.9
Overall (6019)	2985	74.3	61.37, 13.44	3.83, 1.14	25.66, 4.39	56.8	3031	63.2	44.21, 15.12	4.04, 1.04	24.32, 3.70	67.0

Activity assessed using N-Ex and ranging from 1 - 5 with higher values reflecting higher amount of physical activity; N, number of participants; M, mean value; SD, standard deviation; BMI, body mass index; no abn., no abnormality in posture test

Differences between test profiles 1 and 2 (aim 2)

The differences between test profiles 1 and 2 are displayed in table 2. Overall, 49.6% of participants completed TP1 and 50.4% of participants completed TP2. Participants who completed TP1 were on average 17 years older (TP1: 61.4 years; TP2: 44.2 years; $F = 1804.366$, $p < 0.001$) and reported a slightly lower level of physical activity (TP1: 3.8; TP2: 4.0; $F = 44.574$, $p < 0.001$). There was no significant difference between males and females in either TP1 or TP2 with regard to age ($F = 0.037$, $p = 0.847$) or physical activity ($F = 3.224$, $p = 0.073$; Table 3-2).

Table 3-2 Results from two-factorial ANOVA on differences between TP1 and TP2 participants

		N	Age (M, SD)	Activity (M, SD)	BMI (M, SD)	Posture (M, SD)
TP1	**f**	2141-2219	61.44, 13.15	3.82, 1.14	25.41, 4.47	0.41, 0.49
	m	735-766	61.15, 14.27	3.87, 1.16	26.59, 4.0	0.48, 0.50
	Overall	2877-2985	61.37, 13.44	3.83, 1.14	25.66, 4.39	0.43, 0.50
TP2	**f**	1839-1918	44.23, 14.58	4.02, 1.02	23.66, 3.59	0.32, 0.47
	m	1022-1116	44.09, 16.04	4.08, 1.07	25.45, 3.62	0.36, 0.48
	Overall	2861-3034	44.18, 15.13	4.04, 1.04	24.32, 3.70	0.33, 0.47
F^{TP}(p)			1804.37 (0.00)	44.57 (0.00)	151.58 (0.00)	65.85 (0.00)
F^{sex}(p)			0.29 (0.59)	3.22 (0.07)	175.76 (0.00)	15.66 (0.00)
F^{TP*sex} (p)			0.04 (0.85)	0.05 (0.82)	5.62 (0.02)	1.15 (0.28)
η^2			0.27	0.01	0.06	0.01

TP1, test profile 1; TP2, test profile 2; f, females; m, males; N, number of participants; F, F-value; p, p-value; η^2, eta square; M, mean value; SD, standard deviation. Activity assessed using N-Ex and ranging from 1 - 5 with higher values reflecting higher amount of physical activity. N ranges due to different number of participants in analyses for different outcome variables.

TP1 participants also had a higher BMI (TP1: 25.7; TP2: 24.3; $F = 151.579$, $p < 0.001$) and a higher frequency of postural abnormalities (TP1: 43%; TP2: 33%; $F = 65.854$, $p < 0.001$) than TP2 participants. There was a significant sex effect on BMI ($F = 175.760$, $p < 0.001$), i.e., males had a higher BMI than females in both TP1 (males: 26.6; females: 25.4) and TP2 (males: 25.5; females: 23.7). There was also a significant TP x sex interaction effect ($F = 5.620$, $p < 0.05$), i.e., males had a 1.2 higher BMI in TP1 and a 1.8 higher BMI in TP2. Finally, there was a significant sex effect on posture abnormalities ($F= 15.658$, $p < 0.001$), i.e., males had higher frequency of postural abnormalities than females in both TP1 (males: 48%; females: 41%) and TP2 (males: 36%; females: 32%; Table 3-2).

Physical fitness by sex, age, BMI and physical activity (aim 3)

3,034 participants with a mean age of 44.18 years (63.2% females) completed TP2. Within this group, overall, fitness status differed significantly with regard to sex, age, BMI and physical activity (please refer to Table 3-3).

Males had significantly higher performance in endurance ($F = 7.139$, $p < 0.05$), strength ($F = 966.464$, $p < 0.001$) and overall fitness ($F = 11.961$, $p = 0.001$) as compared to females. In contrast, females perform significantly better in coordination ($F = 0.736$, $p < 0.001$) and flexibility tests ($F = 326.706$, $p < 0.001$). There was also a significant age effect, i.e. participants in the youngest group (aged 18-39) performed significantly better across all tests as compared to older participants, with medium to high effect sizes (η^2 as low as 0.11 for endurance and 0.23 for overall fitness), except for low effect size for flexibility ($\eta^2 = 0.02$). Age as compared to sex, BMI or physical activity also explained the highest variance in fitness performance. Furthermore, there was a significant effect of BMI on fitness status, i.e. participants with a higher BMI (≥ 27.4) performed significantly worse in all tests. The explained variance is low to medium with the highest effect sizes for overall fitness ($\eta^2 = 0.11$) and endurance ($\eta^2 = 0.12$). Finally, participants with a higher physical activity level had significantly better performance in all fitness tests and overall fitness, with effect sizes ranging between 0.01 and 0.05, except for medium effect size for endurance ($\eta^2 = 0.06$; Table 3-3).

Three groups of TP2 participants, i.e., those in the youngest age group between 18-39 years, those with normal BMI of 18.5-24.9, and those with an activity level of > 180 minutes per week achieved the best fitness results. That is, on average, their mean value was > 100.00 in all four fitness dimensions and overall fitness. Overall, participants in the youngest age group had the highest level of overall fitness (M = 104.78), endurance (M = 103.30) and coordination (M = 103.22), females had the higher level of flexibility (M = 102.39) and males had the highest level of strength (M = 106.54) as compared to all other groups (Table 3-3).

Table 3-3 Results from one-factorial ANOVA on the impact of sex, age, body composition and physical activity on fitness test performance

Parameters		N	Endurance	Strength	Coordination	Flexibility	Overall fitness
	Female (M, SD)	1720-1903	99.62, 9.92	96.22, 7.38	100.63, 9.19	102.39, 8.70	99.49, 9.16
	Male (M, SD)	1004-1109	100.66, 10.11	106.54, 10.55	98.92, 11.18	95.90, 10.72	100.87, 11.24
Sex	F(p)		7.139 (0.01)	966.464 (0.00)	20.736 (0.00)	326.706 (0.00)	11.961 (0.00)
	η^2		0.00	0.25	0.01	0.10	0.00
	18-39 (M, SD)	1029-1144	103.30, 9.22	104.94, 10.33	103.22, 6.39	101.23, 9.92	104.78, 8.48
	40-59 (M, SD)	1274-1384	99.52, 9.52	98.63, 8.23	100.26, 9.40	100.14, 9.42	99.29, 8.62
Age	>59 (M, SD)	421-485	93.35, 9.70	92.37, 7.47	91.68, 13.38	96.70, 11.03	90.46, 9.91
	F(p)		176.506 (0.00)	357.151 (0.00)	268.008 (0.00)	35.864 (0.00)	405.195 (0.00)
	η^2		0.11	0.20	0.15	0.02	0.23
	18.5-24.9 (M, SD)	1732-1872	102.35, 9.37	100.62, 9.66	101.67, 8.49	101.52, 9.73	102.24, 9.15
	25.0-27.4 (M, SD)	527-577	97.98, 9.41	100.18, 10.05	98.58, 11.25	98.81, 9.87	98.22, 9.61
BMI	>27.4 (M, SD)	465-489	93.44, 9.54	98.13, 10.72	95.34, 11.89	96.35, 10.08	93.67, 10.38
	F(p)		185.782 (0.00)	11.970 (0.00)	89.904 (0.00)	60.007 (0.00)	162.042 (0.00)
	η^2		0.12	0.01	0.06	0.04	0.11
	<60 min	566-637	96.83, 9.69	98.73, 9.86	98.80, 10.73	98.39, 10.44	97.37, 9.98
	60-180 min	1086-1163	99.23, 10.04	98.86, 9.36	99.22, 10.61	99.96, 9.69	98.94, 9.84
Activity	>180 min	1020-1141	102.84, 9.48	101.93, 10.42	101.31, 8.91	100.99, 9.87	102.72, 9.62
	F(p)		80.859 (0.00)	33.627 (0.00)	17.748 (0.00)	14.065 (0.00)	66.217 (0.00)
	η^2		0.06	0.02	0.01	0.01	0.05

TP1, test profile 1; TP2, test profile 2; f, females; m, males; N, number of participants; F, F-value; p, p-value; η^2, eta square; M, mean value; SD, standard deviation. Endurance = estimated VO_2max based on walking or step test; strength= jump & reach test; coordination = flamingo test; flexibility = sit & reach test; N ranges due to different number of participants in analyses for different outcome variables. Mean and SD values are z-scores.

3.5. Discussion

Within two years, more than 6,000 participants residing in eight different European countries completed the EFB. With regard to our first research aim, participants who completed the EFB were, on average, physically active and middle aged. Countries such as Denmark, Germany and Slovenia appear to be more successful in promoting the EFB as reflected by higher number of participants in these countries. One explanation might be, that countries across Europe apply different strategies in promoting the EFB, e.g. integration in sport organizations, connect the EFB with other projects or cooperation with companies.

In line with our hypothesis for the second research aim, we found that participants who completed TP1 were older, less physically active, had a higher BMI and higher frequency of postural abnormalities than participants who completed TP2. This also confirms the initial differentiation of the EFB into two test profiles, i.e., TP1 was designed for participants who are older and/or less physically active and may thus have a lower fitness status, and TP2 was designed for participants who are younger and/or more physically active and may thus have a higher fitness status. However, on average, almost 3/4 of all participants reported being physically active for at least one hour per week. This indicates that even though we observed a difference between the two test profiles, the EFB is mainly completed by individuals who engage in physical activity and that persons who are physically inactive may be less likely to complete the EFB. This problem of participation bias in studies on physical exercise and fitness has been described previously (Barreto et al., 2013). More research is needed on how to reach inactive or low-active participants, and specific activity programs must be invented that address the needs of this target group (Cavill et al., 2012; Kohl et al., 2012).

In addition, with regard to the third research aim, our data show that among participants who completed TP2, age, sex, BMI and physical activity engagement are significantly associated with fitness as assessed by the EFB. In line with our hypothesis, males had higher performance in endurance, strength and overall fitness whereas females performed better in tests assessing coordination and flexibility. Participants in the youngest age group had significantly better results in all fitness tests than older participants. This is also in line with previous studies reporting a difference in fitness level in favor of males (Eriksen et al., 2016; Schmidt et al., 2017) and younger age groups (Ekblom et al., 2007; Milanović et al., 2013; Schmidt et al., 2017). Similarly, normal weight participants performed better than obese participants did, and participants in the higher physical activity group had a better fitness status than participants in the low physical activity group. Both findings are in line with previous research on the association between physical fitness and BMI (Farrell et al., 2002; Ross & Katzmarzyk, 2003; Tittlbach et al., 2017) as well as physical fitness and physical activity (Blair et al., 1989; Eriksen et al., 2016; Oja, 2001); albeit most of these studies focused on cardiorespiratory fitness only or did not differentiate between various motor dimensions. In addition, most of these studies were conducted in the US.

In our study, we did not examine the efficacy of the counselling concept that has been developed and is provided to participants after completion of the EFB. As implied in the transtheoretical model (Prochaska & Velicer, 1997) and the corresponding model of health enhancing physical activity (HEPA) stages (Duan et al., 2013), motivation is an important factor for regular engagement in and maintenance of physical activity and similar health-related behaviors (Klemm et al., 2017). Research has shown that an individually tailored counselling by an educated instructor based on a person's fitness status is associated with desired change in health behaviors such as physical activity (Adams, 2003). In the future, we plan to examine whether the EFB can serve as a tool to enhance motivation of study participants to initiate, maintain or enhance engaging in regular physical activity.

Our results should be interpreted in light of the strengths and weaknesses of our study. The main strengths of the EFB are its evidence-based, theoretical background and the inclusion of validated test items that have been used by our research group for many years. This also enabled us to compare the results of EFB participants to normative values that have been developed in the past years and decades (Klemm et al., 2020; Tittlbach et al., 2017). In addition, together with the involved sports, gymnastic or fitness organizations from eight different European countries, we were able to recruit over 6,000 participants aged ≥ 18 years who completed the EFB within two years after its inception. Another strength of the EFB that also distinguishes it from previously published fitness test batteries is that it is available online and provides participants with a detailed summary of test results and suggestions on how to further improve physical fitness. In addition, all data are de-identified and stored in an online database that is available for researchers per request.

However, several limitations of the study need to be noted. The major limitation of this scientific study is the selection and recruitment of study participants, the inclusion and exclusion criteria and lacking representativeness of the study sample which has also been reported in similar previous studies (e.g., (Barreto et al., 2013). As the EFB was mainly created for the practical use within sport, gymnastic and fitness organizations in different European countries, participants aged 18 years and older were included without a standardized recruitment strategy or stratification for criteria which could have influenced the physical activity and therefore fitness status (e.g., social background, education or living status, urban or rural regions). These limitations also do not allow for creating normative values based on the EFB test results. However, it must be noted that the EFB is deliberately designed and promoted as a fitness test that can be completed by any adult person residing in Europe. Thus, by design, we did not apply a standardized recruitment strategy but rather enabled participation of any interested person. In addition, participants completed the EFB on different occasions and in various settings and we do not have information about response rates or how response rates differed between countries. In addition, this heterogeneity is reflected by the different sample sizes in the subgroup comparisons (only 1 and 2 participants in Bulgaria and the Czech Republic compared to more than 1000 in Denmark and Germany), and did not allow us to conduct further analyses, e.g., stratified by country of residence, by age group or by activity level. Furthermore, we deliberately tried to be rather inclusive and the only exclusion criteria for participation in this research were an age < 18 years and one or more items that were answered with “yes” on the PAR-Q. However, the PAR-Q - albeit being a validated and often used tool in similar research studies - does not exclude conditions not related to musculoskeletal or cardiovascular limitations, although they also can influence physical activity (e.g. mental diseases). Another potential limitation of the study are seasonal changes which may impact participants’ self-reported physical activity levels, and we did not adjust analyses for this potential confounding variable. However, the fitness test battery is performed indoors and a potential impact of weather or temperature is unlikely. Finally, physical activity was assessed using the self-reported N-Ex questionnaire. Even though this is a validated questionnaire, it only provides limited information on physical activity and participants are asked to choose one of five categories that best describes their physical activity engagement in a typical week. Future research using the EFB under controlled conditions (i.e., same instructors, similar settings, objectively measured physical activity and representative sample, potentially through population-based randomized stratified sampling of community-dwelling persons) is thus needed to confirm our preliminary results.

Overall, to our knowledge, our study may be one of the first multinational studies that examined the impact of sex, age, BMI and physical activity on four dimensions of health-related fitness using objective and validated motor tests in adults residing in Europe. While the EFB is a long-term initiative, data collection of the EFB is also still ongoing and in the future, more detailed and comprehensive evaluation of the physical activity and fitness status of adults in Europe based on the EFB will be possible. Furthermore, our long-term goal is to develop a European database of fitness test results based on the EFB. Taken together, results from EFB research may be used for comparisons with other regions (e.g., North America) and may also be of value to politicians and stakeholders to inform development of preventive strategies, initiatives or plans specifically targeted to promoting physical activity and health-related fitness in Europe.

3.6. Conclusion

The EFB is an objective tool to assess the current fitness status of individuals aged ≥ 18 years and regardless of age, sex, BMI or physical activity level. The EFB responds to the call of many researchers for use of validated tasks that allow for an estimation of the current fitness status of a person (Godino et al., 2014; Kokkinos et al., 2017; Watkinson et al., 2010). Results from our analysis of over 6,000 adults who completed the EFB in eight European countries showed that TP1 and TP2 were completed by persons from the respective target groups (i.e. less active vs. active), and that fitness is significantly impacted by age, sex, body composition and level of engagement in physical activity. More research is needed to confirm these preliminary findings and to also examine the potential efficacy of the EFB as a tool of motivation to initiate, maintain or enhance engagement in regular physical activity.

4. Manuscript 3: Fit and Healthy in Middle Adulthood - Do Fitness Levels make a Difference

Published as Klemm, K., Brehm, W., Schmidt, S., De Clerck, I. L., & Bös, K. (2020). Fit and Healthy in Middle Adulthood – Do Fitness Levels Make a Difference. Central European Journal of Sport Sciences and Medicine, 30, 33–46. https://doi.org/10.18276/cej.2020.2-04

4.1. Abstract

Strong evidence exists, that fitness is a physical health resource, which serves to protect one´s health. There is still uncertainty about which fitness level provides the best health outcome and which measurements can be used for analysing this question. This cross-sectional study analysed 462 (64.07% female) German middle-aged adults regarding their fitness status, physical activity (Non-Exercise test), body composition (Body Mass Index) and heart-related health status. Motor tests were used to measure the health-related fitness status. The heart-related health status was surveyed by questionnaire and diagnosis was done in part by a physician. Relationships between risk factors and fitness factors are visible during the correlative analysis. They are substantially more visible in the differentiation of people with and without risks. People with low fitness show noticeable risks in activity, Body Mass Index and heart-related health. People with high fitness show health resources for activity, Body Mass Index and heart-related health. This study points out, that all fitness dimensions influence one´s heart-related health in a positive way. Fitness is measured objectively and includes all health-related fitness dimensions such as endurance, strength, coordination and flexibility. Apart from this standardization, we ask for more longitudinal studies and more objective health measurements.

4.2. Introduction

Fitness is a popular term and everyone wants to be “fit”. However, the understanding of fitness is different. Subjective perceptions can be to feel good or to feel strong, to have energy or to have strength. It is common that “being fit” is mostly associated with “being healthy”. What does it mean to be fit or to be healthy? Which fitness level do people need to reach to be healthy?

In this paper, the clarification of terms and their relationships is done based on the model of health-related fitness (HRF) (cf. Figure 4-1) by Bouchard, Blair and Haskell (2012).

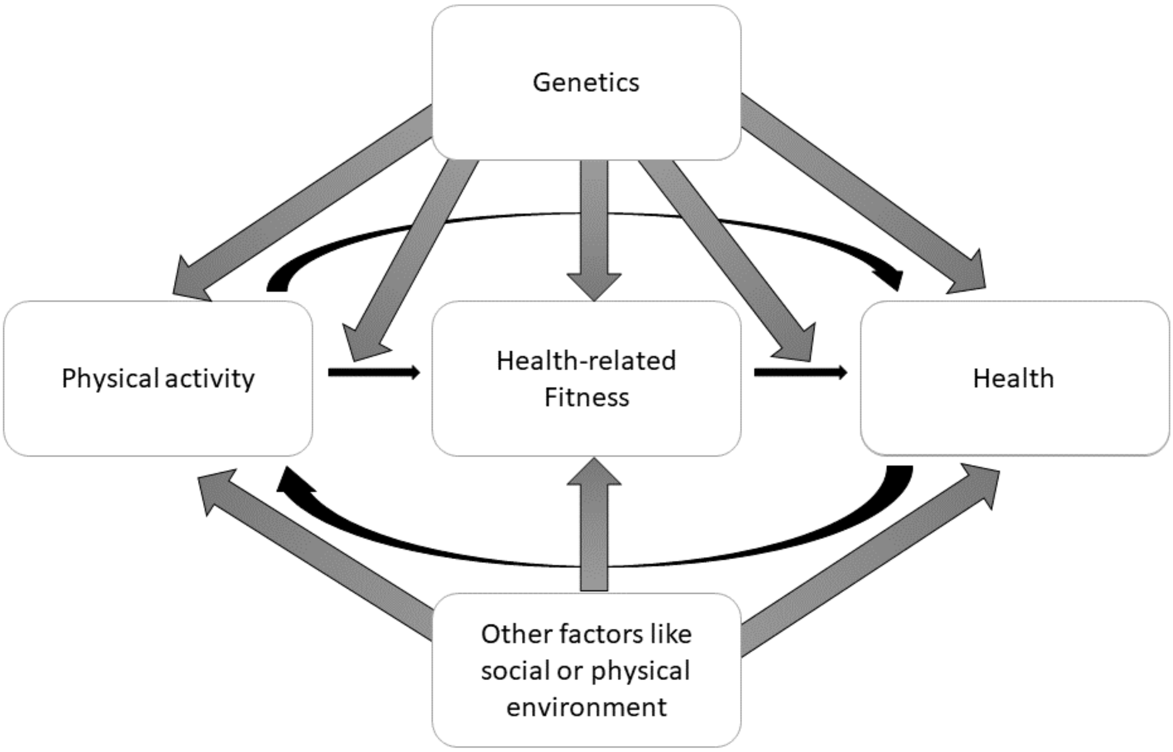


Figure 4-1 Model of health-related fitness (own illustration after Bouchard, Blair and Haskell, 2012)

Defining health is challenging due to the flexible definitions of disease and the progress in treating them and developing resources (Hardman & Stensel, 2009). The World Health Organization (WHO) (World Health Organization, 1986) defines health as a concept emphasizing social and personal resources as well as physical capacities. Antonovsky (1996) adds that physical, social and psychological dimensions are characterized on a continuum with positive and negative poles. Hence, health is not just the absence of disease, but the capacity to enjoy life and to withstand challenges (Bouchard & Shephard, 1994). In their study over 20 years ago, Becker et al. examined parameters influencing health and named them “health-related variables” (1996). Existing current literature in the context of fitness and activity mostly concentrates either on the understanding of health in the physical context (mortality, body composition, blood values etc.) (Warburton, 2006) or on the understanding of health in a psychological context (well-being, enjoying life) (Bize et al., 2007; Olivares et al., 2011). This paper concentrates on aspects of the physical context, in particular the heart-related health of a person.

According to Figure 4-1, Physical Activity (PA), HRF, genetics, and other factors, such as the individual environment, directly influence health. PA is every bodily movement, which is produced by the skeletal muscle that results in energy expenditure (Caspersen et al., 1985). Physical exercise in turn is a subcategory of PA and describes planned and structured activity (ibid). In fact, it aims to maintain or improve components of physical fitness (PF).

There is strong evidence, that fitness is a physical health resource, which serves to protect one´s health (Blair et al., 2001; Woll, 2006). HRF is a component of PF, which evolved out of the examined relationship among fitness, health and PA (Malmberg et al., 2002; Suni et al., 1998). PA favourably affects HRF, whereas sedentary behaviour unfavourably affects it (Bouchard et al., 2012). The most important components of HRF are cardiorespiratory fitness (endurance), muscular fitness (strength), coordination and flexibility (Bös & Mechling, 1985; Caspersen et al., 1985; Oja, 1991; Samitz & Baron, 2002; Suni et al., 1998). Sometimes other components, particularly body composition and posture, are added to this health-related understanding of fitness (ibid.).

Middle age, also called middle adulthood, is defined as the life period between early and late adulthood, including men and women aged 30 to 65 (Berk, 2017; Lademann et al., 2005). Research groups in fitness/activity context mostly focus on men and women aged 40 to 59 (Sandvik et al., 1993; Zadworna-Cieślak & Ogińska-Bulik, 2018). We adopt this definition for further possibilities of comparison.

In middle adulthood, people often have their first contact to age-related health problems. Decrease of muscle mass and bone density, decline in physical capacities, increase of fat mass, sleep complaints, increase in frailty, chronic and cardiovascular diseases characterize typical symptoms of adults in this life period. People at this age experience a midlife crisis or menopause and change roles from caring for children to caring for parents. (Berk, 2017; Dishman et al., 2015; Hardman & Stensel, 2009; Lademann et al., 2005; National Center for Health Statistics, 2009; Rockwood et al., 2011; Zadworna-Cieślak & Ogińska-Bulik, 2018)

In the scientific community, it is strongly evident, that fitness is a meaningful predictor for health (Blair et al., 1989; Blair & Church, 2004; Bös et al., 2012; Brehm et al., 2008; Tittlbach et al., 2017; Williams, 2001). Having a close look at the literature of the last two decades, many reviews investigated, if PA in middle adulthood influences different factors of health (Bize et al., 2007; Blair et al., 2001; Bucksch & Schlicht, 2006; DiPietro, 2001; Kokkinos, 2012; Reiner et al., 2013; Trost et al., 2002; Vuori, 1998;

Wagner et al., 2004; Warburton, 2006). Some reviews addressed the question, which dose of PA has the highest impact (Haskell, 1994; Lee & Skerrett, 2001; Oja, 2001; Warburton, 2006) or which health outcomes were improved the most by PA (Bucksch & Schlicht, 2006; Kokkinos, 2012; Reiner et al., 2013; U.S. Department of health and Human Services, 1996; Warburton, 2006). Nevertheless, up to now, just a few studies exist which examined the coherence of fitness and health in a longitudinal way (Blair et al., 1995; Sandvik et al., 1993; Schmidt et al., 2017). Recently Kokkinos et al. (2017) demanded for extending research with objectively measured aspects of fitness, such as using valid and reliable tests, like the treadmill test for measuring cardiorespiratory fitness. Research groups of Blair (1995) and Sandvik (1993) assessed PF using a treadmill test and bicycle ergometer respectively. Schmidt et al. (2017) assessed health during a laborious health examination conducted by a practicing physician and fitness with 13 motor performance tests in four motor dimensions: cardiorespiratory fitness, strength, coordination and flexibility. Results of this longitudinal study are various; central to the purpose of this paper is, that health limitations rise with increasing age and with decreasing PF.

Among others, the research groups of Sandvik (1993), Myers (2004) and Blair (1989) analysed the effect among cardiorespiratory fitness and mortality risk, according to different stages of fitness. Sandvik et al. and Myers et al. divided their sample in quartiles, according to the result of an exercise test (cycle ergometer or treadmill test). Blair et al. split their sample into quintiles, according to the result of a treadmill test. All three studies reported an inverse reduction of mortality rates when the fitness level increased. Sandvik et al. executed a follow-up of middle-aged men after 16 years. The highest fitness quartile had a relative risk of mortality of 0.54 in comparison to the lowest fitness quartile, though results were adjusted for age, smoking, serum lipids, blood pressure, resting heart rate, vital capacity, body mass index (BMI), PA level and glucose tolerance. Myers et al. executed a follow-up study with men in middle age, too. The highest fitness quartile displays lowest age-adjusted mortality risk in comparison to the lowest quartile (hazard ratio=0.28). Blair et al. executed a follow-up of around eight years, but with middle-aged men and women. For both sexes, relative risk (with highest quintile as reference with 1.0) decreased from 1.0 to 3.44 for men and to 4.65 for women. Further studies (Blair et al., 1995; Kampert et al., 1996; Katzmarzyk et al., 2004) differentiate just two groups: fit and unfit, but confirm the findings of Sandvik, Myers and Blair.

Considering all of this evidence, it seems that a lot has been done so far with regards to examining the construct of HRF, PA and health. However, most of these studies focus on cardiorespiratory fitness. Still there is a need of further research, including objective measures of other fitness aspects such as strength, coordination and flexibility. This is what our study wants to complement, while using objective measures in health-related fitness and heart-related health for our target group of middle-aged adults.

The central aim of this study is to compare middle-aged adult's risks in activity, body composition and heart-related health with their HRF level. Related to this, the research question of this study is in which way the level of HRF influences middle age people's health.

Derived from the afore mentioned studies, the following working hypotheses are proposed:

A higher fitness level relates to a higher activity level.

A higher fitness level relates to better results in BMI.

A higher fitness level relates to a lower number of heart-related health issues.

4.3.Methods

Sample

For the last three years (2015 - 2017), data has been recorded from different executed studies of our research group in Germany. This data has now been analysed for the above-named research question.

The sample includes 462 participants (64.07% female) with an average age of 50.28 years (SD = 4.92) and an average activity level of 3.69 (SD = 1.32), according to the N-Ex classification. The average BMI value is 25.34 (SD = 4.17) and around 9% of the sample suffers from heart-related health issues.

All participants first answered different questionnaires including the Non-Exercise questionnaire (N-Ex) (Jurca et al., 2005) as an activity questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q) (Chisholm et al., 1975) as a health questionnaire. A physician partly (n = 250) diagnosed participants regarding different health issues. Secondly, they performed several motor tests in the dimensions of endurance, strength, coordination and flexibility without a specific order. Additionally, they were measured in height, weight and waist circumference.

Methodology

The sample was analysed for the following parameters: motor test results, body composition, activity and health status. In detail, the analysis integrates one motor test per dimension. For endurance, a step and walking test are taken into account. Both tests are well validated (Aadahl et al., 2013; R. M. T. Laukkanen et al., 1993). Laukkanen et al. for the 2-km walking test and Aadahl et al. for the step test developed algorithms for estimating the VO2max. Further motor tests were a push-up test for strength (number of push-ups), a flamingo balance test for coordination (number of fails) and a sit & reach test for flexibility (reaching length). All tests are well evaluated and used often (Klemm, Brehm, et al., 2017; Tittlbach et al., 2017). BMI represents the body composition. BMI is classified in a bivariate parameter with either a healthy BMI from 18.5 to 24.9 (0) and an unhealthy BMI starting from 25.0 (1). People, who were underweight, were negated because of different health risks and low participant numbers (N=7).

PA is displayed through the N-Ex test (questionnaire from 1=”no physical activity” to 5=”more than three hours physically active per week”) (Jurca et al., 2005). PA in this context is described as “at least moderate intensity, that means with substantial increases in breathing and heart rate” (Bös et al., 2017; Jurca et al., 2005). Activity is calculated into a bivariate parameter as well. According to WHO recommendations (World Health Organization, 2010) and the possible threshold the N-Ex allows, people with an activity level below one hour per week were classified with “1” and people with at least one hour per week of activity with “0”.

Health is measured either by self-assessed health questionnaire and/or by diagnosis from a physician. The physician was not available at all test days. That is why 212 participants just answered the self-assessed health questionnaire. To have the best possible display of heart-related health, we matched the following questions of the self-assessed questionnaire with the cardiovascular diagnosis of the physician:

- Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
- Do you feel pain in your chest, when you do physical activity?
- In the past month, have you had chest pain when you were not doing physical activity?

This diagnosis rated the cardiovascular status of the participant in five categories: (1) chronical manifest, (2) chronical beginning, (3) acute long-term, (4) acute short-term and (5) unremarkable healthy.

In summary, these questions were pooled to the bivariate parameter "heart-related health" with either no heart problems (0) or any heart problems (1). Fitness and activity are identified as heart disease risk factors through studies and meta-analysis in the last few years (Blair et al., 2001; Williams, 2001). Mostly, activity was focused. In our study, the focus lies on fitness including all relevant fitness dimensions.

<u>Statistics</u>

Statistical analysis is separated for sex, but not for age. Regarding the analysed fitness parameters, men and women display great significant differences. The chosen age group of middle-aged people display low mean value differences. Therefore, a comparison regarding age for fitness, activity and BMI was neglected.

First, correlations were calculated. Second, extreme value comparisons were executed due to an assumed limited linear correlation. People at risk concerning activity (less than one hour per week of PA), body composition (BMI ≥ 25.0) and coronary risks (acute heart issues) were compared with people without risk regarding fitness in the dimensions of endurance, strength, coordination and flexibility. It is anticipated, that both groups display great differences in their fitness.

Hypotheses were proven through 1) examining a correlation matrix and 2) examining mean values of extreme groups (with risk, without risk).

The significance level is set for .05 (*significant ≤ 0.05, **highly significant ≤ 0.01). Pearson´s correlations are categorized as low (r ≥ 0.10), medium (r ≥ 0.30) or high (r ≥ 0.50) (Cohen, 1992). Partial eta square (η^2) is as well categorized after Cohen (1992) to low ($\eta^2 \geq 0.01$), medium ($\eta^2 \geq 0.06$) or high ($\eta^2 \geq 0.14$). Calculations are done with IBM SPSS Version 24. All study participants agreed in writing to the usage of the anonymized data for scientific calculations and publications.

4.4. Results

Correlative Relationships between fitness and risk factors

Table 4-1. Correlations between the fitness dimensions and activity, BMI and heart-related health

	Men (n=166)			Women (n=296)		
	N-Ex	**BMI**	**Heart**	**N-Ex**	**BMI**	**Heart**
Endurance	0.46**	-0.39**	-0.19*	0.30**	-0.28**	-0.23**
Strength	0.25**	-0.17*	-0.26**	0.28**	-0.28**	-0.21**
Coordination	0.21**	-0.33**	-0.17*	0.26**	-0.38**	-0.29**
Flexibility	0.19*	-0.23**	-0.18*	0.22**	-0.28**	-0.19**
Fitness overall	0.35**	-0.36**	-0.28**	0.29**	-0.37**	-0.25**

Table 4-1 displays the significant correlations between activity, BMI, heart-related health and all fitness dimensions, which spread from 0.17 to 0.46. Explanation of variance ranges between 3% and 21%.

The highest correlations are visible between activity and fitness, especially at endurance (males = 0.46, females = 0.30). Almost the same values display the correlation between BMI and all fitness dimensions. In particular, endurance shows highest correlation for men and coordination for women in terms of BMI. Correlations between health index and fitness is lower, but for fitness overall, correlations of 0.28 (men) and 0.25 (women) occur.

All three working hypotheses can be verified, though relations are somehow low. The question now is, if correlations between activity, BMI, health index and fitness become clearer through comparing extreme groups (with risk, without risk).

Extreme groups comparison (with risk, without risk) regarding fitness

1) Activity and fitness

Table 4-2. Extreme groups comparison of activity regarding the fitness dimensions in male participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))	31-36	0.58 (0.50)	0.36 (0.49)	0.38 (0.49)	0.38 (0.49)	0.48 (0.51)
Q5 (M(SD))	24-44	0.10 (0.31)	0.16 (0.37)	0.23 (0.42)	0.18 (0.39)	0.08 (0.28)
F		20.277	3.459	1.965	3.152	12.012

P	0.000	0.067	0.165	0.081	0.001
η^2	0.26	0.05	0.03	0.05	0.19

Table 4-3. Extreme groups comparison of activity regarding the fitness dimensions in female participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))	48-66	0.40 (0.49)	0.42 (0.50)	0.52 (0.50)	0.38 (0.49)	0.43 (0.50)
Q5 (M(SD))	46-85	0.11 (0.32)	0.17 (0.38)	0.26 (0.44)	0.18 (0.39)	0.15 (0.36)
F		12.750	8.640	9.753	5.297	10.419
P		0.001	0.004	0.002	0.023	0.002
η^2		0.11	0.07	0.07	0.05	0.09

Activity displays the results of the N-Ex questionnaire. People at risk in activity (Q1) are defined as less than one hour active per week (less than 400kcal energy expenditure per week). The differences between people with and without risk are all significant and partly very high (cf. Table 4-2 and Table 4-3). η^2 varies from 0.03 to 0.26 for men and from 0.05 to 0.11 for women. The greatest differences show the endurance for men and women. The smallest differences occur for men regarding coordination and for women regarding flexibility.

Mean values are scaled from 0 - 1, which allows a direct interpretation with a percentile score. As displayed in Table 4-2 and Table 4-3, 36 - 58% of men and 38 - 43% of women in Q1 have the risk factor inactivity. In the fit group of Q5, only 8 - 23% of men and 11 - 26% of women have the risk factor inactivity.

This result is clear and confirms working hypotheses 1. Low fit people (Q1) more often display the risk factor inactivity, than high fit people do.

2) <u>Body composition and fitness</u>

Table 4-4. Extreme groups comparison of BMI regarding the fitness dimensions in male participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))	31-39	0.84 (0.37)	0.72 (0.46)	0.78 (0.42)	0.75 (0.44)	0.81 (0.39)
Q5 (M(SD))	24-45	0.27 (0.45)	0.47 (0.51)	0.38 (0.49)	0.50 (0.51)	0.21 (0.41)

F	29.259	4.747	14.229	4.089	32.052
P	0.000	0.033	0.000	0.048	0.000
η²	0.33	0.06	0.16	0.06	0.37

Table 4-5. Extreme groups comparison of BMI regarding the fitness dimensions in female participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness
Q1 (M(SD))	51-68	0.48 (0.50)	0.63 (0.49)	0.67 (0.48)	0.48 (0.50)	0.53 (0.50)
Q5 (M(SD))	43-81	0.15 (0.36)	0.24 (0.43)	0.17 (0.38)	0.19 (0.39)	0.09 (0.29)
F		14.352	18.752	43.299	11.670	26.584
P		0.000	0.000	0.000	0.000	0.000
η²		0.12	0.15	0.25	0.09	0.20

BMI represents the parameter for body composition. People at risk concerning body composition display a BMI of 25 or higher (according to WHO classification, (World Health Organization, 2018b)) and therewith have the risk of being overweight.

Differences between people with and without risk are all significant and partly very high (cf. Table 4-4 and Table 4-5). η^2 varies from 0.06 to 0.37 for men and from 0.09 to 0.25 for women. The greatest differences show the overall fitness for men and the coordination dimension for women. The smallest differences occur when looking at flexibility for men and women.

Mean values are scaled from 0 - 1, which allows a direct interpretation with a percentile score.

According to Table 4-4, 19 - 26% of men in Q1 have the risk factor of being overweight, whereas 10 - 22% of women in Q1 display this risk factor (cf. Table 4-5). In the fit group of Q5, 0 - 7% of men and 0 - 2% of women display the risk factor of being overweight.

This result is clear and confirms working hypotheses 2. Low fit people (Q1) more often have the risk factor of being overweight than high fit people (Q5) do.

3) <u>Fitness and heart-related health</u>

Table 4-6. Extreme groups comparison of heart-related health regarding the fitness dimensions in male participants

	n	Endurance	Strength	Coordination	Flexibility	Overall fitness

Q1 (M(SD))	30-35	0.23 (0.43)	0.26 (0.44)	0.19 (0.40)	0.26 (0.44)	0.25 (0.44)
Q5 (M(SD))	24-41	0.03 (0.18)	0.03 (0.18)	0.05 (0.22)	0.07 (0.27)	0.00 (0.00)
F		5.495	7.243	3.999	3.513	7.714
P		0.023	0.009	0.049	0.066	0.008
η^2		0.09	0.10	0.05	0.06	0.13

Table 4-7. Extreme groups comparison of heart-related health regarding the fitness dimensions in female participants

	n	**Endurance**	**Strength**	**Coordination**	**Flexibility**	**Overall fitness**
Q1 (M(SD))	47-66	0.16 (0.37)	0.17 (0.38)	0.22 (0.42)	0.10 (0.31)	0.15 (0.36)
Q5 (M(SD))	45-83	0.00 (0.00)	0.00 (0.00)	0.01 (0.11)	0.02 (0.14)	0.00 (0.00)
F		10.332	9.374	19.248	3.395	8.213
P		0.002	0.003	0.000	0.068	0.005
η^2		0.09	0.08	0.13	0.03	0.07

The heart-related health index includes coronary risks, built up through health questions and a diagnosis by a physician.

People with the risk factor for coronary risk have been classified by a physician or confirmed this risk with a self-assessed questionnaire.

The differences between people with and without risk are all significant and partly very high (cf. Table 4-6 and Table 4-7). η^2 varies from 0.03 to 0.26 for men and from 0.05 to 0.11 for women. The greatest differences show the endurance for men and women. The smallest differences occur regarding coordination for men and flexibility for women.

The mean values are scaled from 0 - 1, which allows a direct interpretation with a percentile score. As displayed in Table 4-6 and Table 4-7, 19 - 26% of men and 10 - 22% of women in Q1 have the risk factor coronary risk. In the fit group of Q5, only 0 - 7% of men and 0 - 2% of women have the risk factor coronary risk.

This result is clear and confirms working hypotheses 3. Low fit people (Q1) more often have coronary risk than high fit people (Q5) do.

4.5. Discussion

In summary, these results suggest first tendencies regarding the statement “fitter people are healthier people” and “the more fit the healthier”. The above shown aspects of activity, body composition and heart-related health display mostly definite results for male and female subjects in relation to their fitness level. All working hypotheses can be confirmed.

The relationships between risk factors and fitness factors are visible during the correlative analysis. They are substantially more visible in the differentiation of people with and without risks. People with low fitness show noticeable risks in activity, BMI and heart-related health. People with high fitness show health resources for activity, BMI and heart-related health.

Activity (measured with N-Ex) and fitness show the clearest relationship. It is evident, that especially the endurance dimension displays a strong relationship with fitness as well as the overall fitness value. Flexibility and activity display low relations. These results are in line with our expectations.

Body composition, measured with BMI, displays an expected clear relationship to the fitness dimensions. In those dimensions, where body mass needs to be moved (endurance dimension), overweight and obese people have considerable disadvantages. With female participants, coordinative-weak women are most overweight.

Heart-related health, measured with a questionnaire and a physician’s diagnosis, displays clear relationships to fitness as well. The extreme value comparison suggests that there exists a threshold, and no strict linear relation between fitness and heart-related health exists. However, these results provide further support for people with high fitness to have better health chances.

It is unfortunate that the study includes some limitations. One source of weakness of this study is the sample bias. Though part of the sample was gathered in a random-control study, altogether subjects are on average fit and healthy. It is more striking that within this group of limited variances, those clear relationships between activity, body composition, heart-related health and fitness can be observed. It can be assumed, that a more representative sample displays even clearer results.

Additionally, heart-related health in parts and activity are measured via questionnaires that subjects answered by themselves. Health is a broad construct as well (World Health Organization, 1986). Body composition and heart-related health cover just a small part of this construct. Furthermore, self-assessed health and objectively diagnosed health are summed up for having one comparable parameter of health. Finally, yet importantly, this study presents cross-sectional data. No statement can be made regarding the question, if people with a higher coordination or flexibility level stay healthier over the long term, for example. As stated in the introduction, long-term studies focusing on cardiorespiratory endurance are numerous, but studies including the further health-related fitness dimensions are hard to find. A concrete next step needs to be a follow-up study regarding the motor dimensions displayed in our study. This point will be broadly described in the conclusion section.

This study points out, that the level of fitness relates to one's health, and vice versa, in a positive way. Precisely, a higher fitness level in endurance, strength, coordination and flexibility relates to lower issues in heart-related health.

In sum, this study presents a tendency other research groups can confirm with their studies (Blair et al., 1989; Myers et al., 2004; Sandvik et al., 1993; Schmidt et al., 2017; Tittlbach et al., 2017). However, some challenges still remain and need to be focused on in further studies:

1) Assessing fitness objectively must be standardized. Not just assessing one aspect of PF like cardiorespiratory, which is evidently linked to health issues (ibid.). Measuring a broad fitness status including strength, coordination and flexibility can reveal further acknowledgments, which at this moment no one thought of in detail (Brehm et al., 2005).

2) Having a clear standard for displaying fitness levels. Different authors structured fitness levels in quintiles, quartiles or according to the metabolic equivalent of task (MET). This study focused on quintiles according to percentile ranks. In general, all of these studies generated their reference group out of their own sample.

3) Assessing health with the help of practicing physicians or the like. This study only integrated BMI and heart-related health in part as objectively measured health aspects. However, the aim must be to have a fully objective measured health construct (Brehm et al., 2005).

4) There should be a demand to examine different specific health aspects that are influenced through an increase of PF. In completion to 1), PF should be measured in different dimensions to have concrete recommendations for the practical field. In general, more studies should be executed as longitudinal studies to get statements regarding the dose-response-relationship.

5) Current studies focus on sedentary behaviour as a higher risk factor than inactivity (Katzmarzyk, 2010; Thorp et al., 2011). We could not examine this parameter with our sample. The focus of further research needs to have a full investigation of this risk factor as well.

This study is part of an overall evaluation of the EFB. This instrument aims to measure fitness and additional aspects such as body composition and posture to figure out individual recommendations for each participant. Every participant gets a certificate and seven pages of detailed feedback according to the results achieved. Based on this, they receive recommendations by their trainer e.g. for attending special sport classes. (Klemm et al., 2017) This study confirms the assumption that a rise in PF, independent of peoples´ fitness level, can improve the heart-related health of a person. This is the fundamental motivation of the EFB and its developers.

The most common reasons for Europeans to be physically active is to improve their health (54%) or to improve their fitness (47%) (European Commission, 2018). With the help of the EFB counselling, they get an idea of how to raise their fitness level and therewith to improve their health. Still, there is a need for more studies with standardized tests, broad samples and executed longitudinal style to tell participants what they will benefit from. For practical relevance it can be stated, that an increase in structured and well-planed activity (Tittlbach et al., 2017) increases fitness and therewith increases health.

5. General Discussion

This chapter serves on the one hand as summary of the displayed three manuscripts and on the other hand as guide for researchers and practitioners who work in the field of fitness testing in Europe.

Chapter 5.1 describes the methodological issues, which occurred during the research. In detail, strengths and suggestions for improvement are shown. In chapter 5.2, a summary of the insights of the studies are presented. In concluding all three manuscripts, a general impression of the health-related fitness status in Europe is describable and got explained in detail. Therewith, these chapters sum up the ending point of this project.

Chapter 5.3 takes this up besides other things and names implications for research, which (could or should) evolve out of this thesis. Due to the high practical relevance of this thesis now and in future, chapter 5.4 takes a close look at the implications for practice for the different stakeholders. Those two chapters and the concluding chapter 6 define the starting point of the project, named in the Preface.

5.1. Methodological issues

This original research study combines some strengths and limitations, which are observed in detail and considered when interpreting. Aspects that are named in the three manuscripts are not repeated here. Focus is on general strengths and limitations, which are observed for the overall picture.

Strengths

- Real life: This study is executed in real life conditions. People took part which were interested in the EFB and not due to calls for a research study. There is no need to adjust the data for recommendations or further calculations. Statements of these data are reliable, because they were collected under real life conditions. These relevant results lead to direct statements for practitioners and consequences for further research in this field. Though it must be mentioned that this relates to the limitation of missing representativeness (see limitations).

- Broad target group: Due to the accessibility to all people in the partner countries, people of every age and both sexes took part at the EFB. Target groups like women, which are often underrepresented in research studies, display a great part of participants and lot of female data is gathered here.

- Multinationalism: Due to the European focus of the EFB project, data of eight countries (effective 2020) is collected and therewith summed up or compared. In addition, the EFB is an ongoing project and with local partners in every country (f.e. sport clubs etc.) the ongoing of the project is ensured. Long-term developments and comparisons are possible. Furthermore, more organisations in further countries are interested in joining the project; a sustainable and growing database is ensured. Nonetheless, the subjectivity of data gathering need to be considered.

- Digitalisation: The EFB concept is based on modern interpretation of fitness testing. With the unique EFB online data platform, the processes of input, output, re-testing and data export are digitalised. In addition, the organisational level is digital as well with an access-controlled platform for EFB instructors, multipliers and project partners. For public, a real time dashboard with a limited view on data is available online as well.

Limitations

- Internal evaluation concept: The evaluation was an internal process with internal motivation but also by order of the EU. This might lead to a subjective view on concept and improvements. However, there were used quantitative evaluation methods during those studies.

- Structural-based differences between the project countries: This includes the education of multiplier and instructors as well as the execution of the test items. With different materials like the handbook for instructors, instruction videos and furthermore, a unite education and execution concerning the

EFB should be possible. Nevertheless, the countries have their own limitations and strengths regarding these aspects. For example, countries as Slovenia and Bulgaria do not have their own multiplier, so Austrian multipliers educated them. This might have good consequences for a unite education but also individual aspects if these countries are not considered. In addition, the settings, which the EFB was executed in, are not transparent. Setting information is not recorded due to data protection issues (i.e. if below five people participate at a company it would be easy to reproduce).

- Data origination: Due to different structures, methods and focuses the entered data is in a strong need of control. Automatic proofs occur for unrealistic values directly at the online data platform. But, mistakes which might on the first sight be realistic cannot be proven there, e.g. a 1.60m high women with a reach height of 2.50m. The used data set is proven for minimal and maximal values and for missing values manually. In addition, names of events were proven for anomalies e.g. names of persons.

- Representativeness: After proving, it is assumed that all values are real values executed by real persons. Nevertheless, as it is a so-called field-study with real life conditions, we cannot allow or forbid people to participate due to our representability. Furthermore, this is an EU-funded project and results of these projects are accessible for all EU citizens. In fact, the sample is real but not representative. In addition, it is selective because the EFB is offered at special occasions and settings.

Altogether, limitations can be reduced and taken as challenges for future research. In 2019, many efforts were made in the practical field e.g. to have a common understanding of test execution in all countries. Therefore, videos of test items were created and published online (Deutscher Turner-Bund, 2019). For a consistent education of instructors, an online education course was established by ISCA (International Sport and Culture Association, 2019). One challenge will be to handle the growing data set regarding the health-related fitness data. Regarding the quality of data, the online data platform mow includes more proof of realistic values than two years before. For example, the jumping height must be higher than the reaching height at the jump and reach test.

The strengths will be continued and extended. This refers to the two points of internationalisation and digitalisation. Both aspects are important for a sustainable usage and acceptance by all relevant stakeholders of the EFB.

5.2.The health-related fitness status of Europeans

The three studies serve all in a different way for a complete understanding of the health-related fitness status of Europeans. In a first step, results of every single study are summed up. In a second step, these were summed up to a whole.

With the first manuscript, research question 1: How do instructors, participants and experts rate the EFB concept (overall structure, test profiles and items)? was answered. The concept of the EFB regarding acceptance, feasibility and psychometric properties were proved and considered as good. All direct related and relevant stakeholders were involved in this study. With those results and resulting improvements in concept and test items, a basis for upcoming testing of the health-related fitness status of Europeans was built.

With the second manuscript, research question 2: Who participated at the EFB? was answered. Altogether, the fitness status of around 6,000 Europeans was analysed. The proved overall concept as well as the evidence for health-relation, result in displaying the participants and their characteristics. Both test profiles addressing different target groups reach their aim and present the health-related fitness status of the participating countries. The EFB reaches people from 18 to 89, men and women and low active to very active people.

With the third manuscript, research question 3: Does the health-related fitness status, displayed by the EFB results, relate to participants health? was answered. With data of around 460 people, the research group proved if the health-orientation of the EFB was given. The underlying statement, that fitter people are healthier people, was investigated. This study is an important factor for presenting the health-related fitness status. Just through those results, the EFB team is sure to have a scientific-based justification for the EFB in reaching the aimed target group. These results justify the purpose and recommendation of the EFB. The aim to enhance the fitness status to improve health (specific aspects as body composition or heart conditions) is scientifically proven now. In addition, the study confirms and strengthens the relation between activity and fitness. The counselling after executing the EFB is focussed on the quality-based increase of physical activity.

Overall, the EFB is

1) a reliable instrument for people to get an idea of their individual fitness status and an appropriate counselling
2) an instrument for displaying the health-related fitness in Europe
3) a promotion instrument for clubs and organisations

On these three levels, the EFB serve as instrument with development potential regarding e.g. digitalization and dissemination. This potential, plus further implications in the field of practice and research are described in chapters 5.3 and 5.4.

Compared to other public tests like the Eurofit test (Oja & Tuxworth, 1995), the EFB is transparent for instructors, participants and further interested groups. That makes a direct implementation and realisation much easier. In addition, the EFB includes a broad counselling for a sustainable effect after the test execution. There exist a lot more national fitness tests in Europe which are described in the first manuscript (Klemm et al., 2017). A health-orientation combined with motor fitness tests only exists for the EFB. The well-evaluated concept as well as the scientific proven and objective test items are key to a longitudinal observation and careful interpretation of the health-related fitness status in Europe. Careful, because data is not representative and not collected under controlled conditions.

Meanwhile, in statistics as the Eurobarometer (European Commission, 2018) or the WHO European Health report (World Health Organization Europe, 2015) the talk is of physical activity or sport. Fitness is only named as motive but not as parameter to measure, though in many studies fitness is displayed as important as physical activity regarding the health benefit. Nevertheless, aim of the EFB is to measure the fitness to enhance the physical activity. With the fundamental assumption, that physical activity influences the fitness level of a person (cf. chapter 1.2.1), the EFB is the tool to improve physical activity in a sustainable way as the European Commission, the WHO and the scientific community ask for. That means, that it is not only the health-related fitness status of Europeans the EFB is able to present but also based on this to promote physical activity in a direct way.

5.3.Implications for research

From 2015 to 2019, around 30 studies connected with the EFB were done by the project partners. Those studies mostly were students works or unpublished theses which focussed aspects as feasibility of the test concept, acceptance by stakeholders or psychometric properties of the test items (Abbott, 2019; Demilde et al., 2016; Klemm et al., 2017; Maes et al., 2016). After publication of the EFB, studies focussed on improvement and dissemination, for example they developed new concepts and guidelines for special settings or target groups (Bäuerle, 2019; Betz, 2019; Keller, 2019; Weindl, 2020).

However, results and insights of these small studies associated with this thesis are the basis for upcoming studies and research. Following implications for research are recommended:

1) Research in the field of physical activity and health-related fitness are strongly connected. The relation between those two concepts and their reciprocal influence is well-evaluated. The EFB combines those two important concepts as well; with the knowledge about the health-related fitness status, people know how to be physically active and therewith influence again their fitness status. Nonetheless, we ask for further studies regarding the health-related fitness. In many studies, it is just seen as a co-parameter, but it needs to be observed and proven in detail. This needs to be executed carefully with including the next implications.
2) The EFB includes objective measurements for the health-related fitness dimensions endurance, strength, coordination and flexibility. Many studies in the last years have done research on cardiorespiratory fitness and sometimes on muscular fitness as well (Ekblom-Bak et al., 2019; Farrell et al., 2002; Ferreira et al., 2012; Kokkinos et al., 2017). However, objective measurements for a complete health-related fitness status were rarely used. The EFB test items are well proven and used in longitudinal studies as well. With the usage of such test items, research in the field of health-related fitness is more reliable and more comparable. Flexibility and coordination as important factors for health need to be seen and included.
3) In relation to 2), further objective measurements for strength, coordination and flexibility performance can be invented and scientifically proven. The used EFB test items sure are well-evaluated and used many times but might be not practicable in some occasions or need to be adapted. Insights or approaches of modern and popular trends in fitness, sport and physical activity as for example Crossfit or high-intensity interval training (HIIT) can be used for new or adapted test items. This is a long process, but only with objective measurements realistic data is gathered and according results or recommendations are given.
4) As named in 3), existing test items can be adapted or improved as well. For example, the EFB project group has invested a lot of time and effort in the plank test. This test was foreseen as strength test with the alternatives push-up test and jump and reach test. Due to missing studies

for this test, reference data for all age groups was not available. Therefore, the plank test was integrated as new test item for generating data over the first years in public and to be able to publish reference data after a few years of collecting. Two years after the EFB publication, data of the plank test was proven for validity and compared to the other strength tests. Results were insufficient due to non-valid results regarding age. That is why the plank test now is an additional test for measuring the body stability. Existing test items and new test items need to be examined regularly for all scientific purposes. If this is adhered to, acceptance by all relevant stakeholders is more likely.

5) Physical inactivity is still one of the biggest health problems the world will face in the next years (Kohl et al., 2012). Therefore, it is one of the biggest questions health and sport scientists try to solve. Sure, the EFB might be just a small part of the solution, but it can be. Studies for bringing the EFB to the inactive people and therefore inventing implementation strategies, concepts or methods are future scientific challenges. The EFB project group tried to do so in the last two years but failed until now. Creative, innovative and individual concepts on international level are needed to face this problem.
6) International research teams need to be supported to share work or to start cooperation. This is surely done in many cases but must be extended. With the experience of the EFB project team, an international project with more than one scientific partner has many benefits. Scientific knowledge is merged, and country-specific methods or approaches can be shared. Sponsors or funders like the EU should support this.
7) It was an important factor of the EFB project group: the collaboration between science and practice. Many researchers face the accusation to work just for the science and to be far away from practice. In projects as the EFB and in the further development of the EFB itself, cooperation is essential. For researchers it is e.g. important for studies to be able to have an appropriate sample, to be able to contact practitioners with a lot of experience or to have appropriate setting or material. Progress in a project as the EFB is reassured through constant communication and exchange between those partners. Success is more likely to follow if partners and maybe customers as well are involved from the beginning.
8) On a very basic level, there exist some EFB-related research topics, which need to be focussed soon. First, as named previously in 5), target group-specific concepts must be invented, executed and scientifically monitored. This includes inactive people, men and people with overweight. Concepts and guidelines for settings where those groups are to find need to be invented, executed and proven. Furthermore, longitudinal studies need to examine if there is a long-term effect and impact of the EFB regarding the enhancement of physical activity and the health-related fitness status. Until now, a small short-term study with a test-retest time of three months relieved small

results in favour of the EFB participants (Weindl, 2020). The sustainability is an important factor for the change of behaviour according to the model described in chapter 1.2.2. That is why this aspect is important to be examined in near future.

9) Altogether, gathered data is ready to be analysed for special research questions, comparisons with other data sets or improvements regarding the EFB itself. Effective June 2020, 8,316 people participated at the EFB. With growing participation numbers, inter-country comparisons are possible and should be done to examine inter alia the different implementation concepts and their success. The ask of a multinational monitoring system regarding health and fitness trends (Lamoureux et al., 2019) can be answered with the EFB as well.

These implications for research are recommendations out of our experience of the EFB project. Detailed recommendations and insights are described in the discussion sections of the three manuscripts. With these nine aspects, further similar projects or studies in the field of health-related fitness on national and international level benefit from our experiences as a scientific partner in an EU project.

5.4. Implications for practice

Besides the scientific community as one important stakeholder, further stakeholders are more likely to find in the practical field. That is why this chapter is as much important as the previous one. In collaboration with those groups, results and according recommendations can be realized and implemented. In addition, the implications for research can just be realized in combination with those stakeholders in some part.

Following implications for practice are recommended:

1) There is a strong need for realistic values about physical activity status and fitness status. Numbers of inactive people in Europe are high, but they might be higher if the data would be gathered through objective measurements. Godino et al. (2014) asked in their paper for objective instruments, because people overestimate their activity level by self-assessment. This might be the same for their fitness status. Only if people have a scientific-based certificate and feedback about their real fitness status, they realize what needs to be done. Instruments as the EFB must be used regularly by sport or fitness clubs and further organizations to counsel regarding a realistic way of enhancing physical activity and therewith the fitness status.
2) As named in the previous chapter, cooperation and collaboration between science and practice is very important. It is also very important for practitioners due to the flood of information and new insights people get every day through media. A good win-win cooperation between science and practice help both sides. Meanwhile, to have a scientific partner is a quality aspect for sport or fitness clubs. Researchers have a high reputation and people trust recommendations, which are scientific based.[4] Those two parties benefit from each other and should not see each other as opponents.
3) In countries as Germany or Austria, there is a long tradition of sports badges, which test for sport skills. Since decades, people in sport clubs compare each other with those tests. However, trend of sport and fitness is towards fitness training or bodyweight training or in general, health-oriented training for staying fit. To follow this trend, e.g. in Germany many sport clubs integrate a fitness centre and focus on general health / activity classes than sport classes. This trend needs to be followed for tests and badges. If people do not train on sport skills anymore (not that much as 20-30 years ago), they need an instrument for measure what they train. A comprehensive test like the EFB includes measurements for endurance, strength, coordination, flexibility and further measurements as BMI or posture, which are extremely important for a health-related fitness status.

[4] I want to emphasize, that this cooperation sure can be dangerous as well. A cooperation like this need to be balanced and scientists should act after the guidelines of good scientific practice.

4) In relation to 3) it is also very important for sport clubs and organizations to stay innovative. In Germany, sport clubs face high competition with further new sport offers on the market (Jütting & Marker, 2011). Integrating new offers in balance with established offers might be a solution for staying able to compete. Nonetheless, this must be in accordance with instructors and trainers.
5) Instructors and trainers are a core factor for establishing new tests like the EFB. According to their will, competence and motivation, a test succeeds or fails. We ask for a high involvement of this group in decision making in sport clubs and further sport organizations. Regarding the EFB, we experienced that good results rise and fall with motivated and engaged instructors. They are the executive body; if they do not accept new developments, methods or concepts, it is not possible to implement them on a sustainable level.
6) Projects as the EFB on international level are very popular. They represent the globalization and internationalization in the sports sector. Many people emphasized it as a strength of the EFB, but it needs to be handled carefully. Such a project works on two levels: on the international and on the national level. In some countries, it was essential for an implementation to present the EFB in the national language. Nonetheless, the comparison with international results is a big advantage. We ask for more international collaborations between sport organizations and clubs, because they face similar challenges and benefit from an international solution.
7) Besides international solutions, another big aspect for sustainability and topicality is digitalization. Traditional sport and health sport face competition by online offers with low obligation, high individualization and high flexibility. It does not mean that traditional sport adapt completely to this kind of offers. However, methods and concepts to combine traditional and modern ways might be a solution. The EFB is one example, where on the one side the traditional test execution with the instructor and the following counselling is precious to execute face-to-face. On the other side, the online data platform allows instructors to get the results directly after the test execution. It is indisputable that as shorter the time between test and results as more understandable is it for participants. Sport or fitness clubs and the executive body of instructors must keep this in mind and try to find possibilities which are realistic and appropriate for their purpose and target group.
8) International collaborations between sport or fitness clubs and organizations need to be supported to share work or to start cooperation. This is surely done in many cases but should be extended. With the experience of the EFB project team, an international project has many benefits. In including as many organisations as possible (if it is beneficial), the acceptance by those countries is given and adaptions for country-specific issues can be followed during the development.

These implications for practice are recommendations out of our experience of the EFB project. Detailed recommendations and insights are described in the discussion sections of the three manuscripts.

Stakeholders in the fields of sport, fitness and health can use these as recommendations or hints for further projects in a practical way.

6. Conclusion and Perspective

The EFB is an international instrument to display the health-related fitness. At this time, the EFB is the only multinational health-related fitness test for adults used in Europe. Concept, scientific character, participants, purpose and target group are proven with those three studies described in chapters 2, 3 and 4. They are considered as good or accordable improvements were made. After two years of real field tests, participant's data were analysed with the help of the unique online data platform regarding the health-related fitness status. This needs to be continued. With further promotion, national and international dissemination strategies, limitations as the different participant numbers per country can be reduced. It is necessary to realize strategies and concepts for special target groups and relevant target groups as inactive people. It is evident, that physical inactivity is one of the biggest health problems for now and in future (Kohl et al., 2012; World Health Organization, 2018a), but though hundreds of papers, publications and reports are published a solution or way of counteracting is not working until now. In 2018, the WHO published the aim of reducing the global inactivity level by 15% and formulated 20 policy actions (World Health Organization, 2018a). They also highlighted the importance of partnerships and working together with partners of different areas and levels. The EFB can be integrated in some of these actions, as for example in programmes across multiple settings or programmes for the least active. Furthermore, the EFB is a data system of fitness data for the European population. For a decrease of physical inactivity and an increase of physical activity, people need a realistic statement regarding their fitness and activity level. People tend to overestimate their physical activity level and their sports involvement (Godino et al., 2014; van Sluijs et al., 2007), that is why an objective and well-evaluated state of the art needs to be executed as basis for a realistic counselling with the aim to reach the physical activity recommendations.

In fact, the EFB now runs by itself, but should not be left alone. Experts and partners need to involve those existing concepts and guidelines, review after a certain time, revise and try further. Therefore, the inclusion of new partners in new countries might be one solution. Furthermore, new partners in already participating countries contribute significant new insights, ideas or knowledge. European events as the Move Week (*MoveWeek*, n.d.) or the European week of sport (Clemente, 2019) bring all together and enhance the idea of being active together. This relates to the most important conclusion to be made; contribute to or strengthen the European Community, as the European Commissioner stated in the quote written down in the introduction: "We can all be active in different ways". Moreover, being active together, reaching aims together and motivate each other is part of the European community and the idea of many national and international organisations, as for example ISCA. Jan Monnet once stated, "Beyond differences and geographical boundaries there lies a common interest". This was said in relation to economy and the challenge of Chinese competition, but it does not need to be restricted to it. A common interest as well is to stay or get healthy, which is an interest for economic aims too. This interest can only be reached in including all health-related areas, as displayed in the introduction. The interaction between sport, physical activity and fitness is one aspect of this complex construct. If the EFB contributes to the complex construct in moving people or motivate them to stay active, the aim of the EFB and the project partners is reached.

References

Aadahl, M., Zacho, M., Linneberg, A., Thuesen, B. H., & Jørgensen, T. (2013). Comparison of the Danish step test and the watt-max test for estimation of maximal oxygen uptake: The Health2008 study. *European Journal of Preventive Cardiology*, *20*(6), 1088–1094. https://doi.org/10.1177/2047487312462825

Abbott, A. (2019). *Development and first evaluation of an instructor questionnaire for the European Fitness Badge (EFB)* [Unpublished master thesis]. Karlsruhe Institute of Technology.

Adams, J. (2003). Are activity promotion interventions based on the transtheoretical model effective? A critical review. *British Journal of Sports Medicine*, *37*(2), 106–114. https://doi.org/10.1136/bjsm.37.2.106

Antonovsky, A. (1996). The salutogenic model as a theory to guide health promotion. *Health Promotion International*, *11*(1), 11–18. https://doi.org/10.1093/heapro/11.1.11

Australian Government Department of Health. (2014). *Fact Sheet: Adults (18-64 years)*. Australian Government Department of Health. https://www1.health.gov.au/internet/main/publishing.nsf/Content/fs-18-64years

Barreto, P. de S., Ferrandez, A.-M., & Saliba-Serre, B. (2013). Are Older Adults Who Volunteer to Participate in an Exercise Study Fitter and Healthier Than Nonvolunteers? The Participation Bias of the Study Population. *Journal of Physical Activity and Health*, *10*(3), 359–367. https://doi.org/10.1123/jpah.10.3.359

Bauer, S., Römer, K., & Medizinischer Dienst des Spitzenverbandes Bund der Krankenkassen e. V. (MDS). (2018). *PRÄVENTIONSBERICHT 2018*. https://www.gkv-spitzenverband.de/media/dokumente/krankenversicherung_1/praevention__selbsthilfe__beratung/praevention/praeventionsbericht/2018_GKV_MDS_Praeventionsbericht.pdf

Bäuerle, T. (2019). *Development and practical testing of a strategy for implementing the European Fitness Badge (EFB) in companies* [Unpublished master thesis]. Karlsruhe Institute of Technology.

Becker, P., Bös, K., Opper, E., Woll, A., & Wustmans, A. (1996). Vergleich von Hochgesunden, Normal- und Mindergesunden in gesundheitsrelevanten Variablen (GRV). *Zeitschrift Für Gesundheitspsychologie*, *4*(1), 55–76.

Berk, L. (2017). *Development through the lifespan*. Pearson Education India.

Betz, J. (2019). *Development and implementation of an exercise program for over-weight and obese adults with the help of the European Fitness Badge as diagnostic tool* [Unpublished bachelor thesis]. Karlsruhe Institute of Technology.

Biddle, S. J., & Mutrie, N. (2007). *Psychology of physical activity: Determinants, well-being and interventions*. Routledge.

Bize, R., Johnson, J. A., & Plotnikoff, R. C. (2007). Physical activity level and health-related quality of life in the general adult population: A systematic review. *Preventive Medicine*, *45*(6), 401–415.

Blair, S. N., Cheng, Y., & Holder, J. S. (2001). Is physical activity or physical fitness more important in defining health benefits? *Medicine and Science in Sports and Exercise*, *33*(6 Suppl), 379–399. https://doi.org/10.1097/00005768-200106001-00007

Blair, S. N., & Church, T. S. (2004). The Fitness, Obesity, and Health Equation: Is Physical Activity the Common Denominator? *JAMA*, *292*(10), 1232. https://doi.org/10.1001/jama.292.10.1232

Blair, S. N., Kohl, H. W., Barlow, C. E., Paffenbarger, R. S., Gibbons, L. W., & Macera, C. A. (1995). Changes in Physical Fitness and All-cause Mortality. *Journal of Cardiopulmonary Rehabilitation*, *15*(6), 449.

Blair, S. N., Kohl, H. W., Paffenbarger, R. S., Clark, D. G., Cooper, K. H., & Gibbons, L. W. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Jama*, *262*(17), 2395–2401.

Bös, K. (1987). *Handbuch sportmotorischer Tests*. Verlag für Psychologie, Hogrefe.

Bös, K., Brehm, W., Klemm, K., Schreck, M., & Pauly, P. (2017). *European Fitness Badge. Handbook for Instructors* (Deutscher Turner-Bund, Ed.). https://fitness-badge.eu/wp-content/uploads/2017/03/EFB-Instructors-Handbook-EN.pdf

Bös, K., & Mechling, H. (1985). *International Physical Performance Test Profile: For Boys and Girls from 9-17 Years" IPPTP 9-17"*. Internat. council of sport science and physical education (ICSSPE).

Bös, K., Pfeifer, K., Stoll, O., Tittlbach, S., & Woll, A. (2001). Testtheoretische Grundlagen. In *Handbuch Motorische Tests. Hrsg.: K. Bös* (2., fully revised and exp. ed., pp. 531–569). Hogrefe, Göttingen.

Bös, K., & Schlenker, L. (2011). Deutscher Motorik-Test 6–18 (DMT 6–18). In M. Krüger & N. Neuber (Eds.), *Bildung im Sport: Beiträge zu einer zeitgemäßen Bildungsdebatte* (pp. 337–355). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-94026-7_21

Bös, K., Tittlbach, S., Woll, A., Suni, J., & Oja, P. (2012). FinGer—Physical activity, fitness and health—An international longitudinal study in Bad Schönborn and Tampere. *International Sport Studies*, *34*(2), 42–50.

Bös, K., Worth, A., Opper, E., Oberger, J., Wagner, M., Jekauc, D., & Woll, A. (2009). Motorische Fähigkeit und Aktivität von Kindern und Jugendlichen–Ergebnisse der MoMo–Studie. *Diabetes Aktuell*, *7*(08), 367–371.

Bouchard, C., Blair, S. N., & Haskell, W. L. (2012). *Physical activity and health*. Human Kinetics.

Bouchard, C., & Shephard, R. J. (1994). Physical activity, fitness, and health: The model and key concepts. In *Physical activity, fitness, and health: International proceedings and consensus statement* (pp. 77–88). Human Kinetics Publishers.

Brehm, W., Sygusch, R., & Tittlbach, S. (2008). Gesundheits- und Fitness-Sport als Ressource für Erwachsene. *Sport Und Gesundheit in Der Lebensspanne. Czwalina, Hamburg*, 31–47.

Brehm, W., Wagner, P., Sygusch, R., Schönung, A., & Hahn, U. (2005). Health promotion by means of health sport–A framework and a controlled intervention study with sedentary adults. *Scandinavian Journal of Medicine & Science in Sports*, *15*(1), 13–20.

Bucksch, J., & Schlicht, W. (2006). Health-enhancing physical activity and the prevention of chronic diseases—An epidemiological review. *Social and Preventive Medicine*, *51*(5), 281.

Bundesministerium für Kunst, Kultur, öffentlichen Dienst und Sport. (n.d.). *Das Österreichische Sport- und Turnabzeichen* (Austria). ÖSTA - Österreichisches Sport- und Turnabzeichen. Retrieved 19 May 2020, from http://www.oesta.at/de

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, *100*(2), 126.

Cavill, N., Foster, C., & Richardson, D. (2012). Can sport reach inactive people? A review of literature and practice in the UK. *Journal of Science and Medicine in Sport*, *15*, S346. https://doi.org/10.1016/j.jsams.2012.11.842

Chisholm, D. M., Collis, M. L., Kulak, L. L., Davenport, W., & Gruber, N. (1975). Physical activity readiness. *British Columbia Medical Journal*, *17*(2), 375–378.

Clemente, C. (2019, August 19). *European Week of Sport 2019* [Text]. Sport - European Commission. https://ec.europa.eu/sport/week_en

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155.

Corbin, C. B., Pangrazi, R. P., & Franks, B. D. (2000). Definitions: Health, fitness, and physical activity. *President's Council on Physical Fitness and Sports Research Digest*.

Crump, C., Sundquist, J., Winkleby, M. A., Sieh, W., & Sundquist, K. (2016). Physical Fitness among swedish military conscripts and long-term risk of type 2 diabetes: A cohort study. *Annals of Internal Medicine*, *164*(9), 577–584. https://doi.org/10.7326/M15-2002

Demilde, M., D'Hondt, L., Lankriet, S., Van den Bulke, K., Van Houtte, B., & De Clerck, I. (2016). *European Fitness Badge: An effective way of promoting the awareness of the importance of health enhancing physical activity.* [Unpublished bachelor thesis]. Artevelde University College Ghent.

Deutscher Olympischer Sportbund (DOSB). (n.d.). *Das Deutsche Sportabzeichen*. Retrieved 17 October 2019, from https://www.deutsches-sportabzeichen.de/

Deutscher Turner-Bund. (2019, August 21). *EFB - Instruction videos*. https://www.youtube.com/playlist?list=PLRHvS0kQVV8Fte1Bt8Jj9n9bOwtTbpDDB

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., Van Mechelen, W., & Pratt, M. (2016). The economic burden of physical inactivity: A global analysis of major non-communicable diseases. *The Lancet*, *388*(10051), 1311–1324.

DiPietro, L. (2001). Physical activity in aging: Changes in patterns and their relationship to health and function. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *56*, 13–22.

Dishman, R. K., Sui, X., Church, T. S., Kline, C. E., Youngstedt, S. D., & Blair, S. N. (2015). Decline in cardiorespiratory fitness and odds of incident sleep complaints. *Medicine and Science in Sports and Exercise*, *47*(5), 960.

Duan, Y., Brehm, W., Strobl, H., Tittlbach, S., Huang, Z., & Si, G. (2013). Steps to and correlates of health-enhancing physical activity in adulthood: An intercultural study between German and Chinese individuals. *Journal of Exercise Science & Fitness*, *11*(2), 63–77.

Ekblom, B., Engström, L.-M., & Ekblom, Ö. (2007). Secular trends of physical fitness in Swedish adults. *Scandinavian Journal of Medicine & Science in Sports*, *17*(3), 267–273. https://doi.org/10.1111/j.1600-0838.2006.00531.x

Ekblom-Bak, E., Ekblom, B., Söderling, J., Börjesson, M., Blom, V., Kallings, L. V., Hemmingsson, E., Andersson, G., Wallin, P., & Ekblom, Ö. (2019). Sex-and age-specific associations between cardiorespiratory fitness, CVD morbidity and all-cause mortality in 266.109 adults. *Preventive Medicine*, *127*, 105799.

Ekblom-Bak, E., Hellénius, M.-L., Ekblom, Ö., Engström, L.-M., & Ekblom, B. (2010). Independent associations of physical activity and cardiovascular fitness with cardiovascular risk in adults. *European Journal of Cardiovascular Prevention & Rehabilitation*, *17*(2), 175–180. https://doi.org/10.1097/HJR.0b013e32833254f2

Eriksen, L., Grønbæk, M., Helge, J. W., & Tolstrup, J. S. (2016). Cardiorespiratory fitness in 16 025 adults aged 18–91 years and associations with physical activity and sitting time. *Scandinavian Journal of Medicine & Science in Sports*, *26*(12), 1435–1443. https://doi.org/10.1111/sms.12608

European Commission. (2008). *EU physical activity guidelines. Recommended policy actions in support of health-enhancing physical activity*. Brussels.

European Commission. (2018). *Special Eurobarometer 472. Report Sport and Physical Activity*. https://ec.europa.eu/sport/news/2018/new-eurobarometer-sport-and-physical-activity_en

Farrell, S. W., Braun, L., Barlow, C. E., Cheng, Y. J., & Blair, S. N. (2002). The relation of body mass index, cardiorespiratory fitness, and all-cause mortality in women. *Obesity Research*, *10*(6), 417–423.

Ferreira, M. L., Sherrington, C., Smith, K., Carswell, P., Bell, R., Bell, M., Nascimento, D. P., Pereira, L. S. M., & Vardon, P. (2012). Physical activity improves strength, balance and endurance in adults aged 40–65 years: A systematic review. *Journal of Physiotherapy*, *58*(3), 145–156.

Finger, J. D., Krug, S., Gößwald, A., Härtel, S., & Bös, K. (2013). Kardiorespiratorische Fitness bei Erwachsenen in Deutschland: Ergebnisse der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1). *Bundesgesundheitsblatt - Gesundheitsforschung - Gesundheitsschutz*, *56*(5–6), 772–778. https://doi.org/10.1007/s00103-013-1672-y

Gelius, P., Tcymbal, A., Abu-Omar, K., Mendes, R., Morais, S. T., Whiting, S., & Breda, J. (2020). Status and contents of physical activity recommendations in European Union countries: A systematic comparative analysis. *BMJ Open*, *10*(2), e034045. https://doi.org/10.1136/bmjopen-2019-034045

Godino, J. G., Watkinson, C., Corder, K., Sutton, S., Griffin, S. J., & van Sluijs, E. M. (2014). Awareness of physical activity in healthy middle-aged adults: A cross-sectional study of associations with sociodemographic, biological, behavioural, and psychological factors. *BMC Public Health*, *14*(1), 421. https://doi.org/10.1186/1471-2458-14-421

Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., & Ekelund, U. (2012). Global physical activity levels: Surveillance progress, pitfalls, and prospects. *The Lancet*, *380*(9838), 247–257. https://doi.org/10.1016/S0140-6736(12)60646-1

Hamer, M., & Steptoe, A. (2009). Prospective study of physical fitness, adiposity, and inflammatory markers in healthy middle-aged men and women. *The American Journal of Clinical Nutrition*, *89*(1), 85–89. https://doi.org/10.3945/ajcn.2008.26779

Hardman, A. E., & Stensel, D. J. (2009). *Physical activity and health: The evidence explained*. Routledge.

Haskell, W. L. (1994). JB Wolffe Memorial Lecture. Health consequences of physical activity: Understanding and challenges regarding dose-response. *Medicine and Science in Sports and Exercise*, *26*(6), 649–660.

International Sport and Culture Association. (2019). *European Fitness Badge course – Online Learning by ISCA*. https://learn.isca.org/courses/european-fitness-badge/

Jensen, M. T., Holtermann, A., Bay, H., & Gyntelberg, F. (2017). Cardiorespiratory fitness and death from cancer: A 42-year follow-up from the Copenhagen Male Study. *British Journal of Sports Medicine*, *51*(18), 1364–1369. https://doi.org/10.1136/bjsports-2016-096860

Jurca, R., Jackson, A. S., LaMonte, M. J., Morrow, J. R., Blair, S. N., Wareham, N. J., Haskell, W. L., van Mechelen, W., Church, T. S., Jakicic, J. M., & Laukkanen, R. (2005). Assessing Cardiorespiratory Fitness Without Performing Exercise Testing. *American Journal of Preventive Medicine*, *29*(3), 185–193. https://doi.org/10.1016/j.amepre.2005.06.004

Jütting, D. H., & Marker, U. (2011). Sportvereine in Deutschland-aktuelle Entwicklungen und Herausforderungen in einer turbulenten Umwelt. *Jenseits von Bier Und Tulpen-Sport, Kultur Und Soziales in Den Niederlanden Und Deutschland*, 183–202.

Kampert, J. B., Blair, S. N., Barlow, C. E., & Kohl III, H. W. (1996). Physical activity, physical fitness, and all-cause and cancer mortality: A prospective study of men and women. *Annals of Epidemiology*, *6*(5), 452–457.

Katzmarzyk, P. T. (2010). Physical activity, sedentary behavior, and health: Paradigm paralysis or paradigm shift? *Diabetes*, *59*(11), 2717–2725.

Katzmarzyk, P. T., Church, T. S., & Blair, S. N. (2004). Cardiorespiratory fitness attenuates the effects of the metabolic syndrome on all-cause and cardiovascular disease mortality in men. *Archives of Internal Medicine*, *164*(10), 1092–1097.

Keller, M. (2019). *Development and execution of a concept for the implementation of the European Fitness Badge into the daily training routine of german sports clubs* [Unpublished bachelor thesis]. Karlsruhe Institute of Technology.

Klemm, K., Brehm, W., & Bös, K. (2017). The European Fitness Badge as a diagnostic instrument for the HEPA concept—Development and evaluation. *Leipziger Sportwissenschaftliche Beiträge*, *58*(2), 83–105.

Klemm, K., Brehm, W., Schmidt, S., De Clerck, I. L., & Bös, K. (2020). Fit and Healthy in Middle Adulthood – Do Fitness Levels Make a Difference. *Central European Journal of Sport Sciences and Medicine*, *30*, 33–46. https://doi.org/10.18276/cej.2020.2-04

Klemm, K., Butzke, M., De Clerck, I., Hoffmann, A., Van Houtte, B., Marschall, M., Reichenbach, C., Trentel Busch, L., & Bös, K. (2017). *Development and Evaluation of the European Fitness Badge* [Research Report]. Institute of sport science.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., & Kahlmeier, S. (2012). The pandemic of physical inactivity: Global action for public health. *The Lancet*, *380*(9838), 294–305. https://doi.org/10.1016/S0140-6736(12)60898-8

Kokkinos, P. (2012). Physical activity, health benefits, and mortality risk. *ISRN Cardiology*, *2012*.

Kokkinos, P., Myers, J., Franklin, B., Narayan, P., Lavie, C. J., & Faselis, C. (2017). Cardiorespiratory Fitness and Health Outcomes: A Call to Standardize Fitness Categories. *Mayo Clinic Proceedings*, *93*(3), 333–336. https://doi.org/10.1016/j.mayocp.2017.10.011

Krakauer, N. Y., & Krakauer, J. C. (2012). A New Body Shape Index Predicts Mortality Hazard Independently of Body Mass Index. *PLOS ONE*, *7*(7), e39504. https://doi.org/10.1371/journal.pone.0039504

Lademann, J., Kolip, P., Deitermann, B., Bucksch, J., & Schwarze, M. (2005). *Gesundheit von Frauen und Männern im mittleren Lebensalter*. Robert Koch-Institut.

Lämmle, L., Tittlbach, S., Oberger, J., Worth, A., & Bös, K. (2010). A two-level model of motor performance ability. *Journal of Exercise Science & Fitness*, *8*(1), 41–49.

Lamoureux, N. R., Fitzgerald, J. S., Norton, K. I., Sabato, T., Tremblay, M. S., & Tomkinson, G. R. (2019). Temporal Trends in the Cardiorespiratory Fitness of 2,525,827 Adults Between 1967 and 2016: A Systematic Review. *Sports Medicine*, *49*(1), 41–55. https://doi.org/10.1007/s40279-018-1017-y

Laukkanen, J. A., Lakka, T. A., Rauramaa, R., Kuhanen, R., Venäläinen, J. M., Salonen, R., & Salonen, J. T. (2001). Cardiovascular fitness as a predictor of mortality in men. *Archives of Internal Medicine*, *161*(6), 825–831.

Laukkanen, R. M. T., Oja, R., Pasanen, M. E., & Vuori, I. M. (1993). Criterion validity of a two-kilometer walking test for predicting the maximal oxygen uptake of moderately to highly active middle-aged adults. *Scandinavian Journal of Medicine & Science in Sports*, *3*(4), 267–272. https://doi.org/10.1111/j.1600-0838.1993.tb00393.x

Lee, C. D., Blair, S. N., & Jackson, A. S. (1999). *Cardiorespiratory fitness, body composition, and all-cause and cardiovascular disease mortality in men*. 8.

Lee, D., Artero, E. G., Xuemei Sui, & Blair, S. N. (2010). Review: Mortality trends in the general population: the importance of cardiorespiratory fitness. *Journal of Psychopharmacology*, *24*(4_suppl), 27–35. https://doi.org/10.1177/1359786810382057

Lee, I.-M., & Skerrett, P. J. (2001). Physical activity and all-cause mortality: What is the dose-response relation? *Medicine & Science in Sports & Exercise*, *33*(6), S459–S471.

Lee, I-Min, Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N., & Katzmarzyk, P. T. (2012). Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. *The Lancet*, *380*(9838), 219–229. https://doi.org/10.1016/S0140-6736(12)61031-9

Maes, K., Van Houtte, B., & De Clerck, I. (2016). *European Fitness Badge: Feasibility study* [Unpublished bachelor thesis]. Artevelde University College Ghent.

Malmberg, J. J., Miilunpalo, S. I., Vuori, I. M., Pasanen, M. E., Oja, P., & Haapanen-Niemi, N. A. (2002). A health-related fitness and functional performance test battery for middle-aged and older adults: Feasibility and health-related content validity. *Archives of Physical Medicine and Rehabilitation*, *83*(5), 666–677.

Marcus, B. H., Eaton, C. A., Rossi, J. S., & Harlow, L. L. (1994). Self-Efficacy, Decision-Making, and Stages of Change: An Integrative Model of Physical Exercise 1. *Journal of Applied Social Psychology*, *24*(6), 489–508.

Martin, B. W., Kahlmeier, S., Racioppi, F., Berggren, F., Miettinen, M., Oppert, J.-M., Rutter, H., Šlachta, R., van Poppel, M., & Zakotnik, J. M. (2006). Evidence-based physical activity promotion-HEPA

Europe, the European network for the promotion of health-enhancing physical activity. *Journal of Public Health*, *14*(2), 53–57.

Miilunpalo, S. (2001). Evidence and theory based promotion of health-enhancing physical activity. *Public Health Nutrition*, *4*(2b), 725–728.

Miilunpalo, S., Nupponen, R., Laitakari, J., Marttila, J., & Paronen, O. (2000). Stages of change in two modes of health-enhancing physical activity: Methodological aspects and promotional implications. *Health Education Research*, *15*(4), 435–448.

Milanović, Z., Pantelić, S., Trajković, N., Sporiš, G., Kostić, R., & James, N. (2013). Age-related decrease in physical activity and functional fitness among elderly men and women. *Clinical Interventions in Aging*, *8*, 549–556. https://doi.org/10.2147/CIA.S44112

MoveWeek. (n.d.). Retrieved 30 March 2020, from https://moveweek.eu/

Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., Yamazaki, T., & Froelicher, V. (2004). Fitness versus physical activity patterns in predicting mortality in men. *The American Journal of Medicine*, *117*(12), 912–918.

National Center for Health Statistics. (2009). *Health, United States, 2009: In Brief* (p. 15).

Oja, P. (2001). Dose response between total volume of physical activity and health and fitness. *Medicine and Science in Sports and Exercise*, *33*(6 Suppl), S428-37; discussion S452-3.

Oja, P. (2008). Health-Enhancing Physical Activity. *Directory of Sport Science, 5rd Ed. United States of America: ICSSPE*, 421–438.

Oja, P. (1991). Elements and assessment of fitness in sport for all. *Sport for All. Proceedings of the World Congress on Sport for All, Held in Tampere, Finland, 3-7 June 1990.*, 103–110.

Oja, P., & Tuxworth, B. (1995). *Eurofit for adults: Assessment of health-related fitness*. Council of Europe.

Olivares, P. R., Gusi, N., Prieto, J., & Hernandez-Mocholi, M. A. (2011). Fitness and health-related quality of life dimensions in community-dwelling middle aged and older adults. *Health and Quality of Life Outcomes*, *9*(1), 117. https://doi.org/10.1186/1477-7525-9-117

Pahmeier, I., Tiemann, M., & Maatmann, H. (2012). Nutzung, Bewertung und Qualitätssicherung primärpräventiver Gesundheitssportprogramme. *B&G Bewegungstherapie und Gesundheitssport*, *28*(01), 22–29. https://doi.org/10.1055/s-0031-1283892

Pate, R. R., Slentz, C. A., & Katz, D. P. (1989). Relationships between Skinfold Thickness and Performance of Health Related Fitness Test Items. *Research Quarterly for Exercise and Sport*, *60*(2), 183–189. https://doi.org/10.1080/02701367.1989.10607435

Pfeifer, K., & Rütten, A. (2017). Nationale Empfehlungen für Bewegung und Bewegungsförderung. *Das Gesundheitswesen*, *79*(S 1), S2–S3. https://doi.org/10.1055/s-0042-123346

Piggin, J. (2019). *The Politics of Physical Activity*. Routledge.

Porst, R. (2009). *Fragebogen: Ein Arbeitsbuch* (2nd ed.). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-91840-2

Prochaska, J. O., & DiClemente, C. C. (1982). Transtheoretical therapy: Toward a more integrative model of change. *Psychotherapy: Theory, Research & Practice*, *19*(3), 276.

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion*, *12*(1), 38–48.

Prochaska, J. O., Velicer, W. F., Rossi, J. S., Goldstein, M. G., Marcus, B. H., Rakowski, W., Fiore, C., Harlow, L. L., Redding, C. A., & Rosenbloom, D. (1994). Stages of change and decisional balance for 12 problem behaviors. *Health Psychology*, *13*(1), 39.

Reiner, M., Niermann, C., Jekauc, D., & Woll, A. (2013). Long-term health benefits of physical activity–a systematic review of longitudinal studies. *BMC Public Health*, *13*(1), 813.

Robsahm, T. E., Falk, R. S., Heir, T., Sandvik, L., Vos, L., Erikssen, J. E., & Tretli, S. (2016). Measured cardiorespiratory fitness and self-reported physical activity: Associations with cancer risk and death in a long-term prospective cohort study. *Cancer Medicine*, *5*(8), 2136–2144. https://doi.org/10.1002/cam4.773

Rockwood, K., Song, X., & Mitnitski, A. (2011). Changes in relative fitness and frailty across the adult lifespan: Evidence from the Canadian National Population Health Survey. *Canadian Medical Association Journal*, *183*(8), E487–E494. https://doi.org/10.1503/cmaj.101271

Ross, R., & Katzmarzyk, P. T. (2003). Cardiorespiratory fitness is associated with diminished total and abdominal obesity independent of body mass index. *International Journal of Obesity*, *27*(2), 204–210. https://doi.org/10.1038/sj.ijo.802222

Samitz, G., & Baron, R. (2002). Epidemiologie der körperlichen Aktivität. *Körperliche Aktivität in Prävention Und Therapie. München*.

Sandvik, L., Erikssen, J., Thaulow, E., Erikssen, G., Mundal, R., & Rodahl, K. (1993). Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. *New England Journal of Medicine*, *328*(8), 533–537.

Schmidt, S., Tittlbach, S., Bös, K., & Woll, A. (2017). Different types of physical activity and fitness and health in adults: An 18-year longitudinal study. *BioMed Research International*, *2017*.

Schnell, R., Hill, P. B., & Esser, E. (2011). *Methoden der empirischen Sozialforschung* (9., aktualisierte Aufl.). Oldenbourg.

Steingrebe, H., Stein, T., Bös, K., & Hoffmann, M. (2018). Biomechanical Analysis of the Knee Joint Load During a Unilateral Sit-to-Stand Movement. In *The open sports sciences journal* (Vol. 11, Issue 1, pp. 78–87).

Strand, S. L., Hjelm, J., Shoepe, T. C., & Fajardo, M. A. (2014). Norms for an isometric muscle endurance test. *Journal of Human Kinetics*, *40*, 93–102. https://doi.org/10.2478/hukin-2014-0011

Suni, J. H., Oja, P., Laukkanen, R. T., Miilunpalo, S., Pasanen, M. E., Vuori, I. M., Vartiainen, T.-M., & Bös, K. (1996). Health-related fitness test battery for adults: Aspects of reliability. *Archives of Physical Medicine and Rehabilitation*, *77*(4), 399–405.

Suni, J. H., Oja, P., Miilunpalo, S. I., Pasanen, M. E., Vuori, I. M., & Bös, K. (1998). Health-related fitness test battery for adults: Associations with perceived health, mobility, and back function and symptoms. *Archives of Physical Medicine and Rehabilitation*, *79*(5), 559–569.

Thorp, A. A., Owen, N., Neuhaus, M., & Dunstan, D. W. (2011). Sedentary behaviors and subsequent health outcomes in adults: A systematic review of longitudinal studies, 1996–2011. *American Journal of Preventive Medicine*, *41*(2), 207–215.

Tittlbach, S., Jekauc, D., Schmidt, S. C., Woll, A., & Bös, K. (2017). The relationship between physical activity, fitness, physical complaints and BMI in German adults–results of a longitudinal study. *European Journal of Sport Science*, *17*(8), 1090–1099.

Tremblay, M. S., Warburton, D. E. R., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., Kho, M. E., Hicks, A., LeBlanc, A. G., Zehr, L., Murumets, K., & Duggan, M. (2011). New Canadian Physical Activity Guidelines. *Applied Physiology, Nutrition, and Metabolism*, *36*(1), 36–46. https://doi.org/10.1139/H11-009

Trost, S. G., Owen, N., Bauman, A. E., Sallis, J. F., & Brown, W. (2002). Correlates of adults' participation in physical activity: Review and update. *Medicine & Science in Sports & Exercise*, *34*(12), 1996–2001.

U.S. Department of health and Human Services. (1996). *Physical activity and health: A report of the Surgeon General*. DIANE Publishing.

van Sluijs, E. M., Griffin, S. J., & van Poppel, M. N. (2007). A cross-sectional study of awareness of physical activity: Associations with personal, behavioral and psychosocial factors. *International Journal of Behavioral Nutrition and Physical Activity*, *4*(1), 53. https://doi.org/10.1186/1479-5868-4-53

Vanhees, L., Lefevre, J., Philippaerts, R., Martens, M., Huygens, W., Troosters, T., & Beunen, G. (2005). How to assess physical activity? How to assess physical fitness? *European Journal of Cardiovascular Prevention & Rehabilitation*, *12*(2), 102–114.

Vuori, I. (1998). Does physical activity enhance health? *Patient Education and Counseling*, *33*, S95–S103.

Wagner, P., Brehm, W., & Sygusch, R. (2004). The seven-sequence intervention: Sedentary adults on their way to fitness and health. *Research in Sports Medicine*, *12*(4), 265–282.

Warburton, D. E. R. (2006). Health benefits of physical activity: The evidence. *Canadian Medical Association Journal*, *174*(6), 801–809. https://doi.org/10.1503/cmaj.051351

Watkinson, C., van Sluijs, E. M., Sutton, S., Hardeman, W., Corder, K., & Griffin, S. J. (2010). Overestimation of physical activity level is associated with lower BMI: A cross-sectional analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 68. https://doi.org/10.1186/1479-5868-7-68

Weindl, F. (2020). *European Fitness Badge as a motivational tool to change physical activity levels – An experimental study in the setting of a fitness club (unpublished master thesis)* [Unpublished master thesis]. Karlsruhe Institute of Technology.

Wen, C. P., Wai, J. P. M., Tsai, M. K., Yang, Y. C., Cheng, T. Y. D., Lee, M.-C., Chan, H. T., Tsao, C. K., Tsai, S. P., & Wu, X. (2011). Minimum amount of physical activity for reduced mortality and extended life expectancy: A prospective cohort study. *The Lancet*, *378*(9798), 1244–1253.

Williams, P. T. (2001). Physical fitness and activity as separate heart disease risk factors: A meta-analysis. *Medicine and Science in Sports and Exercise*, *33*(5), 754.

Woll, A. (2006). *Sportliche Aktivität, Fitness und Gesundheit im Lebenslauf: Eine internationale Längsschnittstudie*. Hofmann.

World Health Organization. (1946). *Constitution*. https://www.who.int/about/who-we-are/constitution

World Health Organization. (1986). *The Ottawa Charter for Health Promotion*.

World Health Organization. (2010). *Global recommendations on physical activity for health.* http://www.ncbi.nlm.nih.gov/books/NBK305057/

World Health Organization. (2018a). *More active people for a healthier world: Global action plan on physical activity 2018-2030*.

World Health Organization. (2018b, September 24). *Body mass index—BMI*. http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi

World Health Organization Europe. (2015). *The European health report 2015*. https://issuu.com/whoeurope/docs/ehr_en_web_01__1_

Zaccardi, F., O'Donovan, G., Webb, D. R., Yates, T., Kurl, S., Khunti, K., Davies, M. J., & Laukkanen, J. A. (2015). Cardiorespiratory fitness and risk of type 2 diabetes mellitus: A 23-year cohort study and a meta-analysis of prospective studies. *Atherosclerosis*, *243*(1), 131–137. https://doi.org/10.1016/j.atherosclerosis.2015.09.016

Zadworna-Cieślak, M., & Ogińska-Bulik, N. (2018). Specificity of health-related behaviours in middle and late adulthood. *Health Problems of Civilization*, *12*(1), 7–13.

Figures

Tables

Abbreviations

ABSI	A body shape index
ANOVA	Analysis of Variance
BiSp	Bundesinstitut für Sportwissenschaft (German Federal Institute for Sport Science)
BMI	Body mass index
Chi^2	Chi-square value
Cf.	Confer
DOSB	Deutscher Olympischer Sportbund (German Olympic Sports Federation)
DTB	Deutscher Turner-Bund (German Gymnastic Federation)
e.g.	For example
EFB	European Fitness Badge
EU	European Union
EwoS	European week of Sport
F	F-value
f	Females
FIT	Four steps from inactivity to health-enhancing physical activity
HEPA	Health-enhancing physical activity
HIIT	High-intensity interval training
HRF	Health related fitness
i.e.	That is to say
ibid.	Ibidem
KIT	Karlsruhe Institute of Technology
M	Mean value
m	Males
MET	Metabolic equivalent of task
N	Number of participants
n.a.	Not available
N-Ex	Non-Exercise Questionnaire
no abn.	No abnormality in posture test
P	Significance
p	p-value
PA	Physical activity
PAR-Q	Physical Activity Readiness Questionnaire
PF	Physical fitness
R	Correlation coefficient
r	Reliability
s, SD	Standard deviation
TP1	Test profile 1
TP2	Test profile 2
VIFA Sport	Virtual technical library of Sport Science
VO_2max	Maximal oxygen consumption
VSG	Verein für Sport und Gesundheitsförderung (club for sport and health promotion)
WHO	World Health Organisation
$\bar{x}$	Mean value
η^2	Eta square

Declaration

Eidesstattliche Versicherung gemäß § 13 Absatz 2 Satz 2 Ziffer 3 der Promotionsordnung des Karlsruher Instituts für Technologie (KIT) für die KIT-Fakultät für Geistes- und Sozialwissenschaften:

1. Bei der eingereichten Dissertation zu dem Thema „European Fitness Badge (EFB) – Development, Implementation and Evaluation of a Europe-wide Fitness Test“ handelt es sich um meine eigenständig erbrachte Leistung.
2. Ich habe nur die angegebenen Quellen und Hilfsmittel benutzt und mich keiner unzulässigen Hilfe Dritter bedient. Insbesondere habe ich wörtlich oder sinngemäß aus anderen Werken übernommene Inhalte als solche kenntlich gemacht.
3. Die Arbeit oder Teile davon habe ich bislang nicht an einer Hochschule des In- oder Auslands als Bestandteil einer Prüfungs- oder Qualifikationsleistung vorgelegt.
4. Die Richtigkeit der vorstehenden Erklärungen bestätige ich.
5. Die Bedeutung der eidesstattlichen Versicherung und die strafrechtlichen Folgen einer unrichtigen oder unvollständigen eidesstattlichen Versicherung sind mir bekannt.

Ich versichere an Eides statt, dass ich nach bestem Wissen die reine Wahrheit erklärt und nichts verschwiegen habe.

Karlsruhe, 28.01.21 K. Klemm

Ort und Datum Unterschrift