Tailored multicomponent intervention for remote physical activity promotion in inactive adults

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List of abbreviations

ANCOVA	Analysis of covariance
BASPO	Bundesamt für Sport
BCT	Behavior change technique
BCW	Behaviour Change Wheel
BMI	Body mass index
DSBG	Department of Sport, Exercise and Health
CAS	Certificate of advanced studies
CI	Confidence interval
EKNZ	Ethics committee of Northwestern and Central Switzerland
GP	General practitioner
MET	Metabolic equivalent
MRC	Medical Research Council
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PAR-Q	Physical Activity Readiness Questionnaire
RCT	Randomized control trial
RR	Relative risk
SD	Standard deviation
SEM	Structural equation modeling
SIMPAQ	Simple Physical Activity Questionnaire
SMS	Short message services
TDF	Theoretical Domains Framework
WHO	World Health Organization

Summary

Background: The health benefits of physical activity are well established and widely recognized. Nevertheless, one third of adults worldwide as well as in Switzerland do not achieve the minimum of 150 minutes of at least moderate physical activity per week. The main reasons for this are a lack of time and a lack of motivation. With regard to individual and societal health consequences, effective programs to promote physical activity are therefore needed.
Interventions to promote physical activity without face-to-face contact seem particularly suitable to reach inactive adults. Telephone coaching as well as regular messages (prompts) or internet-based programs have been shown to result in short-term health-relevant behavior changes. Thereby, individually tailored interventions, as well as the implementation of certain behavior change techniques (e.g. self-monitoring, action planning, barrier management) were found most effective in increasing physical activity. Existing studies mainly assessed the effect on self-reported physical activity. Objectively measured physical activity, long-term effects but also mechanisms of action leading to a change in physical activity behavior have rarely been investigated. Additionally, it remains unknown, which delivery modes are most effective and can best be translated into practice.

Aim: This PhD project aimed to develop a physical activity promotion program and to evaluate different versions to communicate it. The short- and long-term effects of telephone coaching and short message services (SMS) prompting on self-reported and objectively assessed physical activity were investigated. A further objective was to examine, whether psychosocial determinants (e.g. outcome expectations, action planning) of physical activity mediate the effect of the intervention.

Methods: The "Movingcall" study is a three-armed randomized controlled trial with a six-month intervention and a six-month no-contact follow-up period. Two hundred and eighty-eight insufficiently active adults, aged 20 to 65 years, were assigned to three different versions of a physical activity promotion program. A “coaching group” received 12 biweekly telephone coaching sessions. In a “coaching and SMS group” the coaching was extended by four SMS prompts among each coaching session (48 SMS in total). The "control group" received a minimal credible intervention consisting of a single written recommendation. All participants were additionally asked to plan and self-monitor their physical activity behavior on a personal web application. The intervention consisted of evidence-based behavior change techniques and training recommendations in all three study-arms. The intervention content was individually tailored to the preferences and needs of the participants.
Outcome measures were assessed at baseline, after the intervention (6 months) and after the follow-up period (12 months). Self-reported moderate-to-vigorous physical activity (MVPA) in one week was assessed using a standardized interview based on the *Simple Physical Activity Questionnaire*. Additionally, a wrist-worn accelerometer was applied to measure physical activity behavior of the same week objectively. Psychosocial determinants of physical activity as well as participants’ acceptance of the program were assessed via online questionnaires. Between group differences and changes over time in physical activity behavior were computed using linear mixed models. The mediating influences of psychosocial determinants were calculated in structural equation models.

Results: The study population comprised two-thirds women, had a mean age of 42 years (SD = 11) and at baseline the self-reported MVPA was 108 minutes/week (SD = 142). After the six-month intervention, self-reported physical activity increased by 173 minutes/week (95% CI 95 to 252) in the coaching group and by 165 minutes/week (95% CI 84 to 246) in the coaching and SMS group compared to the control group. The increased level of self-reported physical activity was maintained after the follow-up period and the observed group differences persisted. Via accelerometer assessed physical activity, increases of 32 minutes/week (95% CI 0 to 63) in the coaching and 34 minutes/week (95% CI 2 to 66) in the coaching and SMS group compared to the control group were observed. The objectively assessed physical activity of the two intervention groups returned to the baseline-levels after the follow-up period. Group differences persisted in the long-term, as the control group decreased its objectively assessed physical activity level below baseline values. Additional SMS prompts did not lead to a further increase in physical activity at either of the measurement points.
The analysis of the psychosocial determinants of physical activity behavior revealed that the coaching resulted in a sustainable improvement of planning and barrier management. Right after the coaching interventions, there were also positive effects on self-efficacy, outcome expectations as well as on intention. An improvement in these determinants was, however, only weakly associated with increased physical activity. A mediation was only observed for increased objectively assessed physical activity after six months through increases in barrier management.
The telephone coaching was well accepted and rated positively. More than 80% of the coaching as well as the coaching and SMS group and 19% of the control group reported that they were satisfied with the program.

Conclusion: Telephone coaching led to higher physical activity levels in the short and long-term compared to a single written recommendation. The two intervention groups showed a relevant and sustainable increase in self-reported physical activity. However, the maintenance of achieved behavior change needs to be interpreted cautiously, as increases in objectively assessed physical activity returned to baseline after the follow-up period. Additional SMS prompts did not increase the efficacy of the coaching intervention. In accordance with theory and previous literature, the promotion of evidence-based behavior change techniques resulted in positive changes in psychosocial determinants of physical activity. Nevertheless, the intervention's mechanisms of action remain largely unknown, as there was almost no mediation of physical activity by these determinants. Overall, telephone coaching can be considered an effective and well-accepted tool to support adults in adopting a physically active lifestyle.

Zusammenfassung

Hintergrund: Der gesundheitliche Nutzen körperlicher Aktivität ist weitestgehend bekannt und gut belegt. Dennoch erreicht ein Drittel der Erwachsenen weltweit wie auch in der Schweiz das Minimum von 150 Minuten/Woche Bewegung bei mindestens moderater Intensität nicht. Die Hauptgründe sind fehlende Zeit und Motivation. In Anbetracht der individuellen, gesundheitlichen und gesellschaftlichen Konsequenzen braucht es daher effektive Programme zur Bewegungsförderung.
Interventionen zur Bewegungsförderung ohne ein persönliches Treffen scheinen besonders geeignet zu sein, um Erwachsene mit ungenügender körperlicher Aktivität zu erreichen. Telefoncoaching, aber auch regelmässige Erinnerungsnachrichten, sowie internetbasierte Vermittlungsformen erwiesen sich als effektiv, um kurzfristige gesundheitsrelevante Verhaltensänderungen zu erzielen. Individuell zugeschnittene Programme sowie der Einsatz bestimmter Verhaltensänderungstechniken (z. B. Dokumentieren der eigenen Aktivitäten, genaues Planen, Barrierenmanagement) führten dabei am ehesten zu einer Steigerung der körperlichen Aktivität. Bestehende Studien erfassten meistens den Effekt auf die selbstberichtete körperliche Aktivität. Objektiv gemessene körperliche Aktivität, Langzeiteffekte der Interventionen aber auch Wirkungsmechanismen, die zu einer Änderung des Bewegungsverhaltens führen, wurden selten untersucht. Des Weiteren bleibt unklar, welche der zuvor genannten Vermittlungsformen am effektivsten und praktisch umsetzbar sind.

Ziel: Das Ziel dieses PhD Projektes war, ein Programm zur Bewegungsförderung zu entwickeln und die Wirksamkeit verschiedener Vermittlungsformen zu analysieren. Es wurden kurz- und langfristige Effekte von Telefon-Coaching und Kurzmitteilungen (SMS) auf selbstberichtete und objektiv erfasste körperliche Aktivität untersucht. Zudem wurde analysiert, ob psychosoziale Determinanten des Bewegungsverhaltens (z. B. Kosten-Nutzen-Erwartungen, Handlungsplanung) die Wirkung der Intervention beeinflussen.

Methode: Bei der Studie «Movingcall» handelt es sich um eine dreiarmige randomisierte kontrollierte Studie mit einer sechsmonatigen Intervention und einer sechsmonatigen Follow-up-Phase. 288 ungenügend aktive Erwachsene, im Alter von 20 bis 65 Jahren, wurden drei verschiedenen Versionen eines Programmes zur Bewegungsförderung zugeteilt. Die «Coaching Gruppe» erhielt im Abstand von jeweils zwei Wochen zwölf telefonische Beratungsgespräche. Die «Coaching und SMS Gruppe» erhielt zusätzlich zum Coaching vier SMS zwischen den Beratungsgesprächen (insgesamt 48 SMS). Die «Kontrollgruppe» erhielt eine minimale Intervention, bestehend aus einer einmaligen schriftlichen Empfehlung. Alle Teilnehmenden wurden zudem gebeten, ihr Bewegungsverhalten auf einem persönlichen Online-Profil zu planen und zu dokumentieren. Die Intervention bestand in allen drei Studienarmen aus evidenzbasierten Verhaltensänderungstechniken sowie Trainingsempfehlungen. Diese Inhalte wurden individuell den Präferenzen und Bedürfnissen der Teilnehmenden angepasst.
Die Datenerfassung erfolgte vor und nach der Intervention sowie im Anschluss an die Follow-up-Phase. Die selbstberichtete körperliche Aktivität bei mindestens moderater Intensität wurde mittels *Simple Physical Activity Questionnaire,* einem standardisierten Interview*,* erfasst. Das Bewegungsverhalten derselben Woche wurde objektiv, mit einem am Handgelenk getragenen Accelerometer,

gemessen. Die Ausprägung der psychosozialen Determinanten des Bewegungsverhaltens sowie die Akzeptanz der Teilnehmenden gegenüber dem Programm wurden mittels Online-Fragebogen erfasst. Um Gruppenunterschiede im Bewegungsverhalten sowie Veränderungen über die Zeit statistisch darzustellen, wurden lineare gemischte Modelle berechnet. Der vermittelnde Einfluss psychosozialer Determinanten wurde mittels Strukturgleichungsmodellen bestimmt.

Resultate: Die Studienpopulation bestand zu zwei Dritteln aus Frauen, hatte ein Durchschnittsalter von 42 (SD = 11) Jahren und die durchschnittliche selbstberichtete körperliche Aktivität bei mindestens moderater Intensität lag zu Beginn bei 108 Minuten/Woche (SD = 142). Nach der sechsmonatigen Intervention stieg die selbstberichtete mindestens moderate körperliche Aktivität der Coaching Gruppe um 173 Minuten (95 % KI 95 - 252) sowie der Coaching und SMS Gruppe um 165 Minuten (95 % KI 84 - 246) pro Woche im Vergleich zur Kontrollgruppe. Die erreichte Zunahme selbstberichteter körperlicher Aktivität wurde nach der Follow-up-Periode beibehalten. Ebenso blieben die beobachteten Gruppenunterschiede von der Post- zur Follow-up-Messung bestehen. Die mittels Accelerometer erfasste mindestens moderate körperliche Aktivität stieg in der Coaching Gruppe um 32 Minuten (95 % KI 0 - 63) und in der Coaching und SMS Gruppe um 34 Minuten (95 % KI 2 - 66) pro Woche im Vergleich zur Kontrollgruppe. Diese objektiv gemessene körperliche Aktivität der zwei Interventionsgruppen kehrte nach der Follow-up Phase wieder zum Ausgangsniveau zurück. Da die objektiv erfasste körperliche Aktivität der Kontrollgruppe nach der Follow-up-Phase unter dem Ausgangsniveau lag, blieben die Gruppenunterschiede zu Gunsten der Interventionsgruppen auch langfristig bestehen. Die SMS-Nachrichten als Ergänzung zum Coaching führten zu beiden Messzeitpunkten zu keiner zusätzlichen Steigerung der körperlichen Aktivität.
Die Analyse der psychosozialen Determinanten des Bewegungsverhaltens ergab, dass das Coaching zu einer nachhaltigen Verbesserung in den Bereichen Planung und Barrierenmanagement führte. Direkt nach der Intervention zeigte sich ein positiver Effekt auf Selbstwirksamkeit, Kosten-Nutzen-Erwartungen und Intention. Eine Verbesserung der Determinanten war allerdings kaum mit gesteigerter körperlicher Aktivität assoziiert. Einzig die objektiv erfasste körperliche Aktivität nach sechs Monaten wurde durch gesteigertes Barrierenmanagement beeinflusst.
Das telefonische Coaching wurde von den Probanden gut angenommen und positiv bewertet. Über 80 % der beiden Interventionsgruppen (Coaching und Coaching und SMS Gruppe) sowie 19 % der Kontrollgruppe gaben an, dass sie mit dem Programm zufrieden waren.

Fazit: Das telefonische Coaching führte kurz- und langfristig zu einem höheren Level körperlicher Aktivität als eine einmalige schriftliche Empfehlung. Beide Interventionsgruppen zeigten eine relevante und nachhaltige Steigerung der selbstberichteten körperlichen Aktivität. Das Aufrechterhalten von erreichten Verhaltensänderungen muss allerdings mit Vorsicht interpretiert werden, da die gesteigerte objektiv erfasste körperlichen Aktivität nach der Follow-up-Periode zum Ausgangsniveau zurückkehrte. Die SMS-Nachrichten brachten als Zusatz zum Coaching keinen erweiterten Nutzen. Das Vermitteln von evidenzbasierten Verhaltensänderungstechniken führte entsprechend den Erwartungen zu einer positiven Veränderung der psychosozialen Determinanten des Bewegungsverhaltens. Aufgrund der fehlenden Mediation der körperlichen Aktivität durch diese Determinanten bleiben die Wirkungsmechanismen der Intervention weitestgehend unbekannt. Insgesamt erwies sich telefonisches Coaching als eine sehr positiv bewertete und effektive Methode, um Erwachsene bei der Aufnahme von einem körperlich aktiven Lebensstil zu unterstützen.

Chapter 1
Introduction

Chapter 1 Introduction

1.1 The relevance of physical activity

The lack of physical activity has been identified as a major public health problem [4,5]. Recent meta-analyses provide high levels of evidence that the risk for contracting various non-communicable diseases including type 2 diabetes (relative risk (RR) = 1.2) [6], hypertension (RR = 1.19) [7], coronary heart disease (RR = 1.16) [8], breast and colon cancer (RR = 1.3) [4,9,10] as well as depression (RR = 1.2) [11] is associated with physical inactivity. Overall, physical inactivity is an independent and modifiable risk factor for premature all-cause mortality [12,13]. In turn, regular physical activity has been associated with an increased overall wellbeing, healthy aging and lowers the chance of disability in later years [13-16].

With regard to this evidence, the World Health Organization (WHO) recommends that adults participate in at least 150 minutes of moderate or 75 minutes of vigorous aerobic physical activity per week. Additional muscle-strengthening activities and an increased duration of moderate-to-vigorous physical activity (MVPA) is also suggested [17]. Thereby, moderate activities are defined as all sorts of body movements, which result in an energy expenditure that are at least three times higher than at rest [17].

Despite the benefit of regular physical activity, one third of the world's population does not reach the minimum recommended amount of physical activity [18]. In Switzerland 28% of adults (>15 years of age) are considered insufficiently physically active [19]. These physical inactivity patterns contribute to the high burden of non-communicable diseases and constitute a notable challenge to the health-care systems [20]. In Switzerland, 326'310 cases of disease, 1'153 premature deaths and direct medical costs of CHF 1.165 billion were attributed to physical inactivity in 2011 [21].

A reduction in global physical activity during the last decades has been caused by several behavioral and environmental factors [22]. These include urbanization, increased use of motorized transport and sedentary occupations [23-25]. Consequently, physical activity is no longer an integral part of everyday life and needs to be performed consciously. Working aged adults face challenging barriers that prevent them from a physically active lifestyle [26,27]. "Lack of time" (40%), "lack of motivation" (18%) and "medical reasons" (18%) are among the most frequently named barriers for Swiss adults [28].

To prevent non-communicable diseases national and international strategy plans are calling for a paradigm shift in health care [29,30]. The mainly curative treatment of those already affected needs to be replaced by a more holistic approach that integrates the prevention of lifestyle-related risk factors to avoid or delay non-communicable diseases. The promotion of physical activity is thereby a key objective [29,30]. A change in physical activity behavior is, however, subject to complex influencing factors and requires modifications of habits in various areas of life [31]. A sole recommendation, for instance by a family doctor, is frequently insufficient to achieve sustainable behavior changes [32]. In most cases, individuals do not lack the knowledge but the capability to overcome barriers such as "lack of time and motivation" [28]. Additionally, it remains a challenge to reach the target group of inactive individuals [33]. Given these constraints, effective interventions, that target

individuals with the most common barriers for physical activity and support them to sustainably adopt a physically active lifestyle, are needed.
Considering the relevance of physical activity, the present thesis investigates effective methods for the promotion of a physically active lifestyle. This first chapter introduces different aspects of remote physical activity promotion. It further explains the applied theoretical background of physical activity and behavior change. Finally, this chapter describes what needs to be considered when developing and evaluating a behavior change intervention.

1.2 Modes of physical activity promotion

Physical activity is a complex phenomenon that is influenced by personal, social and environmental conditions [34]. Accordingly, research on the promotion of physical activity is very diverse. Interventions range from legislative changes, over environmental modifications to interventions at school or services that support individuals. These interventions generally show small to moderate changes in physical activity levels in the short-term [35].
Interventions aimed at individuals usually provide information and support for the development of motivational and self-regulatory skills. They encourage individuals to overcome their personal barriers in order reach and maintain a physically active lifestyle [36-38]. Interventions for an adult population were traditionally delivered in face-to-face meetings or group sessions [37]. These interventions result in positive moderate effects on self-reported physical activity as well as on cardiovascular fitness [39]. Beyond face-to-face interventions, low-threshold interventions delivered by telephone or internet have been increasingly investigated during recent years [37].
The efficacy of remotely communicated individual physical activity promotion programs is influenced by a variety of intervention components. These include the content of an intervention, the degree of individual tailoring and the communication style of intervention providers (e.g. autonomy supportive communication, health coaching) as well as the delivery mode (e.g. telephone-based, web-based) [40,41]. The relevant evidence to each of these intervention components will be described in the following sections. Behavior change techniques, i.e. the content of remote physical activity programs, will be addressed first.

1.2.1 Intervention content: Behavior change techniques

Behavior change techniques (BCTs) constitute the “active ingredients” of a physical activity promotion program [42]. They are the smallest identifiable components that in themselves have the potential to change behavior. BCTs are observable, replicable and irreducible [42]. Self-monitoring (establishing a method to record daily physical activity) or goal setting (agreement on a daily minimum of steps to be achieved) are examples for commonly used BCTs. During recent years, Susan Michie and her research group elaborated BCT taxonomies that label, define and differentiate the various BCTs [43-45]. Thereby, BCTs are specified independently of their delivery mode and the context in which they are applied [46,47]. The use of these taxonomies enables an accurate description of intervention content in a common language. Standardized definitions allow replicability and facilitate comparison between studies. This is particularly important for the accumulation of evidence in systematic reviews and meta-analysis [43,47]. “CALO-RE” was the first taxonomy that was broadly applied in the field of physical activity promotion. The taxonomy distinguishes 40 BCTs

applicable to increase physical activity and healthy eating [45]. The most recent BCT taxonomy, called V1, was published in 2013. This hierarchically organized taxonomy specifies 93 distinct BCTs and can be applied to various target behaviors [43].
Several reviews and meta-analyses have analyzed which BCTs or combinations of BCTs are most effective to promote regular physical activity. These reviews emphasize the use of the BCT "self-monitoring of behavior" (i.e. regular monitoring and recording of physical activity) as well as "goal setting" concerning the behavior and the outcome of the behavior [41,46]. Further the BCTs "action planning", "social support", "problem solving" and "feedback on performance" have been associated with intervention efficacy [40,46,48-54]. When analyzing the efficacy of physical activity promotion programs, one should consider that the delivery mode of a BCT might even have a larger impact on outcomes than the BCT itself [55]. Nevertheless, the above-mentioned meta-analyses provide valuable information on which intervention contents should be implemented in physical activity promotion programs.

1.2.2 Tailoring

Interventions that are individually tailored were found to be particularly efficacious [38]. Tailoring refers to an individual adaption of the information delivered to the recipient [56,57]. Thereby, individualization can be conducted in different ways. First, an intervention can contain personal information to adapt the appearance for each individual. This implies that an individual's name, age or place of residence is taken into account in an otherwise standardized message. Second, tailoring can refer to feedback. A person is given descriptive, comparative or evaluative feedback concerning his or her specific behavioral goal. The third and most advanced level of tailoring refers to the adaption of the intervention content to the individual. Thereby the intervention content is selected based on assessed theoretical constructs in order to match individual needs and resources [56,58]. Existing research indicates that interventions, which take all three aspects into account, are most efficacious [38]. In addition, an ongoing (dynamic) tailoring over the course of an intervention was found to be superior to a singular adaption of intervention contents at the beginning [59].

1.2.3 Health coaching

Health coaching refers to an increasingly cited concept that has emerged as a promising strategy to initiate behavior changes [60]. The term has been applied broadly for personal health related support and education in a coaching context [61]. More specifically health coaching can been conceptualized as a "goal-oriented, client-centered partnership that is health-focused and occurs through a process of client enlightenment and empowerment" [62]. Likewise, health coaching clearly differs from therapy. Therapy focusses on the recovery of a dysfunction and a patient is instructed on what to do. In contrast, health coaching refers to a client as a whole who is strongly involved in the process of change. The coach collaborates with the client in order to build motivation, confidence and engagement to achieve self-determined goals. These goals should be achieved through a process of self-discovery rather than by the coach's advice [63,64]. Beyond the knowledge of health-relevant behavior, intervention strategies and disease management, a coach requires communication skills and the ability to listen. Accordingly, the importance of a professional training of health coaches is empathized [60].

Health coaching interventions have shown positive effects in a variety of contexts including lifestyle related behavior change, adherence to interventions but also chronic disease management [65-69]. Interventions aimed at preventing non-communicable diseases achieved beneficial outcomes concerning weight reduction, healthier nutrition as well as increases in physical activity [70]. Overall, the person-centered and empowering support in tackling health-related behavior changes seems promising. The rapidly increasing number of studies on health coaching underline the importance and the potential of the approach [71]. However, outcomes of health coaching were most frequently assessed at the end of the intervention and long-term effectiveness has been researched scarcely [69,71]. Furthermore, current reviews stress the heterogeneity of health coaching interventions. The communicated content, the delivery mode, the duration and frequency of interactions as well as the extent to which human contact was provided differ strongly [60]. Which of these intervention strategies are most likely associated with positive health outcomes is currently unknown.

1.2.4 Remote intervention delivery modes

The terms “eHealth” and “mHealth” summarize technically mediated intervention strategies to support individuals or groups without face-to-face contact in health relevant topics [72]. eHealth refers to electronically or internet-based health interventions [73], whereas mHealth is characterized by the use of mobile devices such as mobile phones, smart phones or smart watches [74]. These remotely communicated interventions offer several advantages for physical activity promotion programs. First, participants can be reached at their homes and independently of accessibility to facilities. This reduces barriers such as time and transportation and makes interventions accessible for a wider public. The enhanced anonymity additionally lowers the threshold to participate, as it reduces personal contact barriers (i.e. fear of prejudice). Accessibility is further enhanced, as applied devices such as mobile phones are commonly available and part of everyday life [75-77]. Further, electronically delivered interventions are more cost-effective compared to face-to-face interventions given the reduction in staff and time intensity [76,78]. Overall, technology-supported interventions can be considered more convenient and therefore, particularly suitable for inactive adults with common barriers for physical activity (no time, no motivation) [72]. Telephone-based communication, prompting and internet-based programs are among the most commonly applied remote delivery modes. The current state of research considering these communication modes will be explained in the following sections.

Telephone-based interventions

Interventions by telephone were found to be particularly effective to promote physical activity [37]. The telephone is the most widely used communication tool and enables a personal interaction. This allows the use of health coaching techniques as well as a dynamic tailoring of intervention content to the participants preferences and needs [79]. A first systematic review on telephone contact for the promotion of physical activity and dietary behavior changes concluded in 2007 that interventions were efficacious in increasing physical activity levels [77]. Improvements in self-reported physical activity levels were achieved in healthy adults as well as chronically ill patients. Despite the lack of direct comparison of interventions, Eakin et al. [77] concluded that interventions lasting six to 12 months with 12 or more calls were more efficacious compared to shorter interventions. An update of

this first review confirmed the positive effect of telephone interventions in eliciting short-term behavior changes in 2012 [80].

The communication by phone has the potential to be adopted by governmental agencies or health promotion organization [77]. An example for such a government-funded primary prevention service has been implemented and evaluated in Australia [65,81]. The telephone-based intervention was aimed at adults and was free of charge. Participants (n = 1440) received ten individually tailored calls with an average duration of 13 minutes. After the intervention, which lasted six months participants showed positive changes in body weight, nutritional choices and in physical activity levels [81]. The study indicated that results achieved in controlled-laboratory settings can be effectively translated into practice.

SMS prompting

Periodic prompts represent another remote communication strategy to promote physical activity [82]. These refer to repetitively sent messages without user-initiated request (push notifications) [83]. Messages are used as a reminder, to provide information and to reinforce behavior changes [82,84]. Compared to telephone-based intervention, delivery is less staff-intense, time-consuming and accordingly cheaper [85]. Additionally, prompts are less invasive to everyday lives compared to personal communication [86]. Various devices and delivery modes, such as e-mails, apps or screen-based alerts have been used to submit prompts [82]. Short message services (SMS) by mobile phone are however, the most frequently used and researched mode of delivery [87]. One reason might be that SMS represent an extremely widespread form of communication worldwide. Furthermore, messages are transmitted immediately and are very frequently read within minutes once received [87].

Several systematic reviews on SMS promoting highlight their potential to achieve health related behavior changes. A first systematic review published in 2009 by Fjeldsoe et al. [88] concluded that SMS-based interventions resulted in positive short-term behavior change in preventive health behaviors and in clinical care. Whereby, intervention efficacy was higher in individually tailored interventions. A more recent meta-analysis by Armanasco et al. [89] confirmed positive effects of SMS prompts computing an overall pooled short-term effect of d = 0.24. After a no-contact follow-up period the beneficial effect concerning the changed behavior was still present but smaller (d = 0.17). Authors concluded that interventions lasting six to 12 months were most efficacious and, in contrast to previous reviews, that tailoring was not associated with increased efficacy [89]. The ideal frequency of sending messages is not known to date. However, it was shown that more frequent messages were not necessarily associated with more efficacy [90]. Furthermore, the positive effect of periodic SMS declined over time when no additional regular personal contact with a counselor was provided [91]. Therefore, prompting is most frequently applied in combination with other intervention strategies. The isolated impact of text messages, which goes beyond other intervention strategies, cannot be quantified so far [89].

Web-based interventions

In terms of reach and scalability, web-based interventions offer the greatest potential [92,93]. Web-based physical activity promotion programs usually comprise education, automated computer-tailored feedback as well as access to study staff via e-mail or through chat rooms [94]. A comprehensive review by Joseph et al. [95] indicated that a close majority (61%) of internet-based physical

activity interventions targeting adult populations were found to be efficacious. In contrast to previous reviews [96], effects were observed in the short, as well as in the long-term. However, only 20% of included studies incorporated a delayed follow-up assessment [95]. Concerning cost-effectiveness, internet-based interventions are superior to face-to-face interventions as they allow to reach a greater number of individuals at lower cost [97,98]. Generally, web-based interventions require a more active involvement of participants (e.g. participants need to gather information themselves). It is therefore not surprising that high dropout rates and non-usage-attrition represent a key concern of these interventions [95]. The average dropout rate in web-based physical activity interventions is about 22% and was found to be even higher in interventions lasting more than six months [94,95]. An ongoing utilization of the web-based intervention content is however key to achieve sustainable behavior changes [99]. Therefore, web-based interventions are frequently complemented by peer support, counselor support, phone contact or e-mail reminders in order to increase engagement [95,100].

Objectives of future research

The preceding paragraphs illustrate, that diverse remote communication strategies are efficacious in promoting physical activity [37]. Overall, remote interventions have proven equally efficacious compared to face-to-face interventions [80,101] but their self-rated acceptability was found to be higher [72,102].

Independent of the delivery mode, existing reviews on remote physical activity promotion highlight similar methodological limitations and research gaps. First, there is a clear call for increased evaluation of longer-term outcomes following the end of an intervention [37,69,80,89,95]. To date, it is difficult to draw conclusions about the sustainability of interventions as few studies implemented adequate follow-up periods without contact to participants. Second, future studies are requested to include objective assessment of physical activity [36,37,95]. So far, physical activity was most frequently assessed by questionnaires or in interviews [37,103]. These self-reported assessment methods are time-saving and allow a differentiation between types of activities [104]. They are, however, prone to recall bias, over reporting and social desirability [105-107]. Especially in intervention studies, in which participants cannot be blinded towards group allocation, a resulting risk of bias needs to be considered [108]. This limitation might be reduced if self-reported measures were supplemented by pedometers or accelerometers [109]. These measurements do not allow conclusions on the specific type of activity. However, accelerations of the body are associated with energy expenditure whose increase is an objective of physical activity promotion [110,111]. Finally, it remains unknown what delivery mode, or what combination of delivery modes, are most effective. Remote physical activity promotion programs often combine multiple communication strategies and results cannot be attributed to specific intervention components [40,72,89]. However, insights into specific delivery modes would enable a targeted use of technologies to achieve health related behavior changes. This is considered particularly relevant, as advanced technological devices are increasingly part of everyday life [75]. To overcome this gap in the literature, studies with multiple intervention arms that investigate different combinations of intervention delivery are needed [72].

1.3 Theoretical foundation

Theory-based physical activity promotion has been shown to be more efficacious in increasing physical activity levels than atheoretical interventions [50,112]. A theoretical foundation explains determinants (theoretical constructs like motivation or outcome expectations) of physical activity and potential pathways for behavior change [113,114]. This allows the identification of theoretical constructs, which need to be addressed in an intervention. Theories further explain mechanisms of action of specific BCTs and thereby inform the selection and individual tailoring of BCTs [115,116]. Finally, a theory explains what constructs mediate physical activity behavior changes and thus allows to analyze why an intervention reaches an effect [117].

In the present thesis, the theoretical foundation consists of the Behaviour Change Wheel framework and the MoVo Process Model.

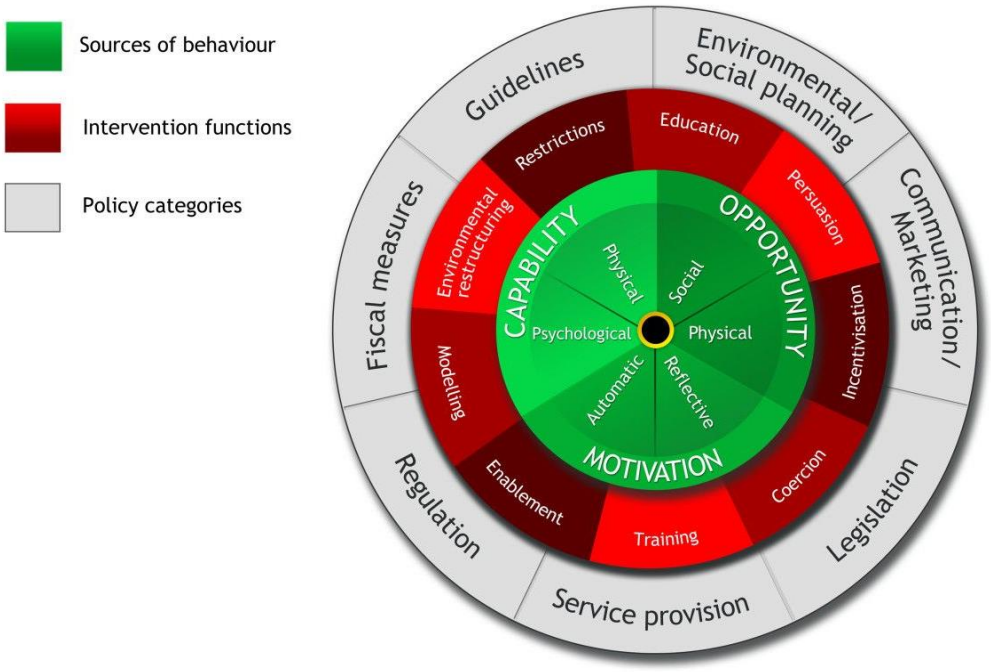

Figure 1: The Behaviour Change Wheel framework by Michie et al. [118]

The Behaviour Change Wheel (BCW) framework provides a comprehensive approach to identifying aspects that influence a behavior (see figure 1) [42,118]. It consists of three layers. The COM-B Model is located in the middle of the framework. This model explains a behavior change (B) as a result of the change in one or more components of psychological or physical capability (C), the social or physical opportunity (O), as well as automatic and reflective motivation (M). This COM-B Model is supplemented by the Theoretical Domains Framework (TDF) [119,120], which provides a more detailed subdivision of determinants, which influence behavior. The TDF summarizes concepts of numerous behavioral theories into 14 domains. These domains can correspond to the COM-B Model

as follows: capability (knowledge; cognitive, interpersonal and physical skills; memory, attention and decision processes; behavioral regulation), opportunity (social influences; environmental context and resources), and motivation (reinforcement; emotions; social/professional role and identity; beliefs about capabilities; optimism; intentions; goals; beliefs about consequences) [119,120]. Surrounding the COM-B is a layer with nine intervention functions. These are broad categories, through which an intervention can change a behavior. Intervention functions can further be subdivided and contain the specific BCTs according to the V1 taxonomy [43]. The relation of intervention functions and specific BCTs to the COM-B Model and domains of the TDF is specified in mapping matrices. These matrices complement the framework and help to decide which BCT should be applied to influence a specific theoretical domain [42,115]. Finally, the outer layer comprises policy categories. These are broad categories through which an intervention can be implemented (e.g. service provision). Overall, the BCW framework combines context, intervention as well as behavioral theories and links these to the BCT taxonomy. This enables a holistic understanding of behavior change.

The MoVo Process Model explains physical activity behavior according to six causally linked determinants (see figure 2) [121,122]. Doing so, the model incorporates elements of existing behavior theories and distinguishes between motivational (Mo = motivation) and volitional (Vo = volition) determinants of physical activity. The six determinants are self-efficacy, outcome expectations, strength of the goal intention, self-concordance of this goal intention, action planning and barrier management. These determinants of the MoVo Process Model can be allocated to theoretical domains of the TDF [119]. However, the model ads information by assuming a causal sequence for concepts that are specifically relevant for physical activity behavior.

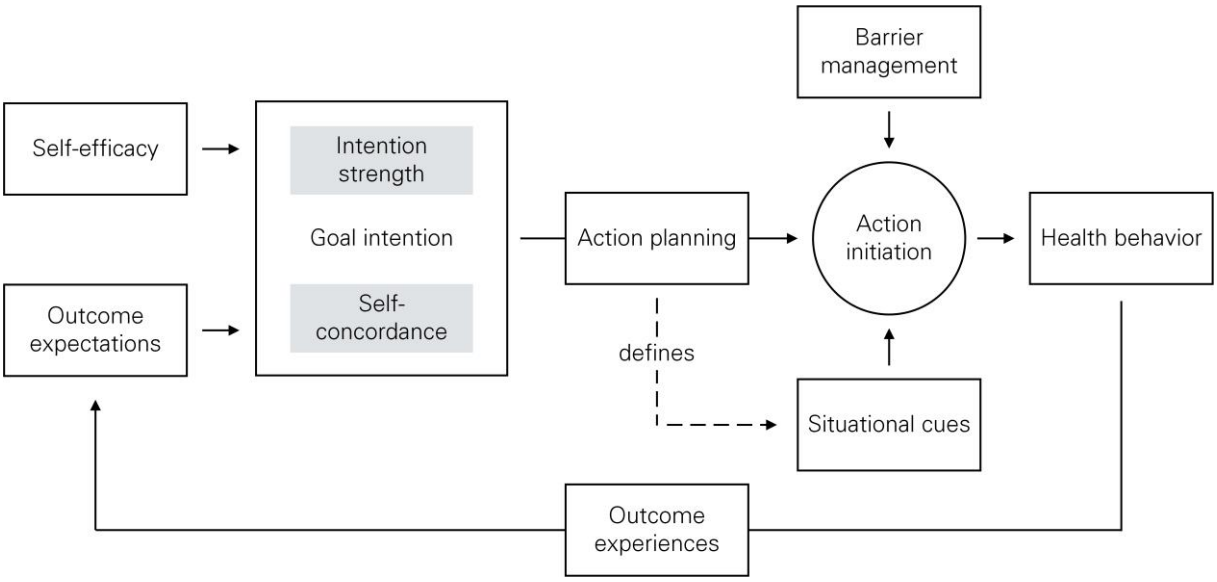

Figure 2: The MoVo Process Model by Fuchs et al. [121]

The key assumption in behavioral theories is that interventions can target change in a determinant (e.g. outcome expectations) which in turn will lead to a change in behavior [123]. Some studies have tested the proposed mediating mechanism of underlying determinants [117]. One study on the

MoVo process model, for example, concluded that a short and long-term increase in physical activity was mediated by an effect of the intervention on intention strength. Increases in physical activity level were additionally mediated by action planning in the short-term and by barrier management as well as by self-concordance in the long-term [121]. These findings are partially in accordance with other mediation analyses applying varying conceptualizations of determinants. Two recent reviews concluded that in particular self-regulatory skills (e.g. planning, scheduling, self-monitoring) are key mechanisms for the promotion of higher physical activity levels [117,124]. However, overall only few studies examined theoretical constructs and identified causal predictors for physical activity behavior change. There is even less research concerning the maintenance of changed behaviors. The two mentioned reviews therefore emphasize the need for studies investigating these working mechanisms of physical activity interventions [117,124].

1.4 Development of a physical activity program

Experience from previous studies should be taken into account when developing and evaluating an intervention to promote physical activity. The Medical Research Council (MRC) Framework for the Development and Evaluation of Complex Interventions, summarized these experiences and helps to recognize and adopt appropriate methods [125,126]. Doing so, the framework specifies aspects considering the development, feasibility, evaluation, reporting as well as the implementation of complex interventions.

The development of a complex intervention should be informed by an underlying theory, by existing evidence as well as by practical considerations. All these considerations should lead to a "logic model" which explains causal assumptions on why an intervention should be efficacious. The feasibility of the developed procedure should then be tested in a pilot study [125].

Subsequently, the intended effect of the program on behavioral or health related outcomes is assessed in a full-scale evaluation study. The pure efficacy does, however, not explain, how a complex intervention should be implemented or adapted in order to achieve its effects in a real world setting [127]. Therefore, the importance of a process analysis is emphasized. Process evaluation refers to the assessment of fidelity (whether the intervention was delivers as intended), dose (the quantity of the intervention) as well as the context in which observed effects were achieved [127,128]. Especially if interventions are tailored, a precise documentation of intervention delivery is needed to enable conclusions on observed outcomes [127]. Furthermore, the acceptance of interventions should be analyzed because successful implementation depends on acceptability of deliverer and recipients [129]. The MRC framework also recommends that mechanisms of an observed impact should be examined. The analysis of previously defined causal assumptions as well as hypothesized mediators contribute to a better understanding of observed effects [125].

Finally, the latest update of the MRC specifically emphasized the importance of accurate reporting to enable replication of studies and evidence synthesis in systematic reviews. It is recommended to publish a study protocol for complex interventions. Thereby, reporting should follow established guidelines (i.e. SPIRIT [130], CONSORT [131], TIDieR [132]). A precise description of the intervention will support the implementation of evidence-based programs in practice, which represents the final step of the framework [125].

Chapter 2
Aims of the thesis

Chapter 2 Aims of the thesis

This PhD project aimed to develop and evaluate a remote physical activity promotion program for insufficiently physically active adults. We aimed to analyze the efficacy of telephone coaching and SMS prompting by comparing three different versions deliver the program.

The developed program needed to be communicated without any face-to-face contact and aimed to combine intervention components that have proven to be effective. Doing so, we intended to provide a personal and easy to implement approach to help adult individuals adopt a physically active lifestyle. The different modalities to communicate the program were to be compared in a three-armed randomized control study. Existing gaps in the literature should be tackled by analyzing long-term effects and by assessing self-reported as well as objectively assessed physical activity. Thereby the project aimed to contribute to the evidence of which intervention components are most effective to promote physical activity.

Main aims of the PhD project

Aim 1: To evaluate the short-term effect of telephone coaching with and without SMS prompting on the physical activity levels in insufficiently active adults.

Aim 2: To investigate the long-term effect of telephone coaching with and without SMS prompting on physical activity levels in insufficiently active adults.

Aim 3: To explore if psychosocial determinants of physical activity mediate the effect of telephone coaching with and without SMS prompting on physical activity levels.

Outline and hypothesis

Publication 1: Study protocol

The first publication of this PhD is the study protocol. This paper describes the rational for the study, the content of the physical activity promotion program and the precise procedure within the three-armed randomized control trial.

Publication 2: Effect of coaching and prompting on physical activity levels

The second publication contains the analyses of the short and long-term efficacy of coaching and prompting for physical activity promotion (Aim 1 and 2). Acceptance and fidelity were analyzed and discussed as well.

We hypothesized that telephone coaching with SMS prompting would result in a greater and more sustainable increase in physical activity compared to coaching alone and that both coaching

conditions would show higher physical activity levels compared to a control group with minimal intervention.

Publication 3: Mediation of changes in physical activity through psychosocial determinants

The third publication addresses the working mechanisms by which telephone coaching and SMS prompting influences adults' physical activity level (Aim 3).

We hypothesized that changes in psychosocial determinants of physical activity mediate the effect of telephone coaching and SMS prompting on participants' physical activity level.

Chapter 3
Publication 1

Coaching and prompting for remote physical activity promotion: Study protocol of a three-arm randomized controlled trial (Movingcall)

Authors:

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Protocol

Coaching and Prompting for Remote Physical Activity Promotion: Study Protocol of a Three-Arm Randomized Controlled Trial (Movingcall)

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Abstract: *Background*. Physical inactivity is currently seen as one of the biggest global public health issue. Remote physical activity (PA) promotion programs are expected to be effective if they are individually tailored and include behavior change techniques, personal coaching, and regular prompting. However, it is still not fully understood which intervention components are most effective. This paper describes the rationale and design of a study on an individually tailored remote PA promotion program comparing the efficacy of coaching and prompting with a single written advice. *Methods*. In total, 288 adults (age 20 to 65 years) were randomly assigned to three different intervention arms of a 6-month-long PA promotion program. A minimal intervention group received a single written PA recommendation. The two remaining groups either received telephone coaching sessions (n = 12 calls) with or without additional short message service (SMS) prompting (n = 48 SMSs for each participant). Data assessment took place at baseline, at the end of the intervention, and after a six-month follow-up-period. The primary outcome of the study was self-reported PA. Objectively assessed PA, psychosocial determinants of PA, well-being, body mass index (BMI), and adherence were assessed as secondary outcomes. *Conclusion*. Findings of this three-arm study will provide insight into the short and long-term effects of coaching and prompting for PA promotion.

Keywords: physical activity promotion; remote; telephone coaching; SMS prompting; inactive adults

1. Introduction

Physical inactivity is associated with various non-communicable diseases and rising health care costs. As an independent risk factor for cardiovascular disease, physical inactivity accounts for 9% of premature deaths globally [1]. Adults should engage in at least 150 minutes of moderate or 75 minutes of vigorous physical activity (PA) per week [2]. Based on self-reports, approximately 30% of the adult population worldwide as well as in Switzerland do not reach these minimal recommendations [3,4]. Physically inactive lifestyles have been linked to technological developments, mechanization, an increased use of motorized transport, and an increase in sedentary leisure-time activities [4].

The lack of time and motivation represent the main self-reported barriers for leisure time PA in working-aged adults [3,5]. To achieve PA-related behavior changes, adults need support to overcome personal barriers.

Environmental approaches, interventions in social settings (e.g., the workplace), and personal interventions that focus on motivational aspects have been proven to be effective in promoting PA [6].

On an individual level, multicomponent strategies are used to encourage participants to incorporate regular PA in their daily lives. Individually tailored interventions (which consider demographic characteristics and the current behavior) based on empirically validated theories are considered most effective [7].

During recent years, an increasing interest has been observed in interventions delivered without a face-to-face interaction. Mobile phone or web-based communication modes are commonly available and enable reach to a wide population. [8]. Compared to face-to-face interventions, remotely delivered programs are considered more cost-effective [9]. An additional benefit is the reduction of time, transportation, and personal contact barriers (i.e., fear of prejudice) [10]. Within remote interventions, telephone contact to provide feedback or to facilitate behavior changes were most effective for promoting self-reported PA [8]. The personal communication enables a further individualization of intervention content and the use of health-coaching techniques. According to Olsen [11], health-coaching refers to a goal-oriented, client-centered, and health-focused interactive partnership between the coach and the participant that is based on a process of enlightenment and empowerment. Combined with other modalities (e.g., print), telephone delivery has shown similar effects to face-to-face interventions [12]. Hence, telephone-based coaching lasting 6–12 months that includes 12 or more calls has been proven effective [13]. The potential to disseminate individually tailored telephone coaching has recently been demonstrated in a population-based study in Australia. After a six-month period with 10 coaching sessions, 1440 participants reported significant improvements in PA levels and body weight [14].

Web-based behavior change interventions include the use of (self-navigated) educational information, computer-tailored feedback, goal-setting and self-monitoring applications, and/or access to a counsellor via e-mail or through chat rooms [15]. An existing meta-analysis indicates positive changes in PA levels [16]; however, effect sizes are small. Depending on the level of interactivity, web-based interventions suffer from low engagement and high retention that are associated with decreased effectiveness [16].

Periodic prompts represent another remote communication strategy for PA promotion [17]. Periodic prompts are messages sent multiple times without a user-initiated request. They are often delivered as short message services (SMSs) by phone. These intervention have the advantage that 90% of obtained SMS are read within minutes once received [18]. Messages are used as a reminder, to provide feedback, or to share information on strategies to facilitate behavior change [17]. A previous meta-analysis showed a small-to-moderate positive effect of SMS prompting on preventive health behaviors [19]. Thereby messages sent at varying times though out the day and the week seem to be more effective, as they prevent habituation and communicate more "social presence" [20].

Behavior change techniques (BCTs) constitute the "active ingredients" of PA interventions. Independent of their delivery mode and context, BCTs can be categorized according to the V1 Taxonomy developed by Michie et al. [21]. Previous meta-analyses pointed out the effectiveness of certain BCTs to change PA behavior [22–24]. In particular, *self-monitoring of behavior* has been associated with intervention effectiveness [24]. Self-monitoring requires the recording of frequency, intensity, or type of PA and makes individuals regularly aware of their current behavior [25]. Existing meta-analyses and reviews [22–24,26–31] further underline the importance of *goal setting* concerning the behavior and the outcome of the behavior. They additionally emphasize the use of *action planning*, *social support*, *problem solving*, *feedback on performance*, *review of behavior goals*, *instruction on how to perform the behavior*, and *information about health consequences*. Furthermore, a recent meta-analysis by Samdal et al. [32] showed the importance of an autonomy-supportive and person-centered communication mode.

Increases in PA are accompanied by improvements in overall well-being [33] and changes in psychological variables which moderate PA participation (e.g., self-efficacy) [31]. Only few studies examined the effects of PA promotion after a follow-up period without intervention and thus data on long-term outcomes are scarce [8,34]. Additionally, PA levels are usually assessed via questionnaires (e.g., 7-Day Physical Activity Recall [35], International Physical Activity Questionnaire [36]) which

are effected by recall and social desirability bias. To date, objective measures (e.g., accelerometer, pedometer) have rarely been used to examine the impact of interventions to promote PA [37].

In summary, there is clear evidence for short-term behavior changes through remote delivery of BCTs. However, it remains unclear which intervention components are most effective and can be translated into practice. In order to gain a better understanding of which specific elements of an intervention result in behavior change, studies with multiple intervention arms and different combinations of intervention components are needed [38]. Furthermore, the maintenance of PA-related behavior change needs to be evaluated across longer periods of time.

Aim of the Study

The main goal of the "Movingcall" study is to evaluate a remote individually tailored PA promotion program based on individually assigned BCTs. More specifically, the following three research questions are addressed: First, what is the short-term effect of remote telephone coaching with and without SMS prompting on self-reported and objectively assessed PA levels in inactive adults compared to a control condition (written information about recommended levels of PA; minimal intervention)? Second, what is the long-term effect (six-month follow-up without contact with participants) of the intervention compared to a control condition? Third, how does the intervention impact on psychological determinants which are involved in the regulation of exercise behavior, and do these determinants mediate the effect of the intervention on PA behavior?

2. Materials and Methods

2.1. Study Design

Movingcall is conceptualized as a three-arm randomized controlled trial (Figure 1). The three study arms differ in terms of the delivery mode of the intervention: A "control group" received a single written recommendation at the beginning of the intervention (minimal intervention). A "coaching group" received 12 biweekly telephone coaching sessions. A "coaching and SMS group", similarly received 12 biweekly telephone coaching sessions which were extended by two SMS messages per week. Data assessment took place at baseline, at the end of the six-month intervention, and after a six-month follow-up period without contact with the participants. The study was conducted at the Department of Sport, Exercise, and Health at the University of Basel, Switzerland.

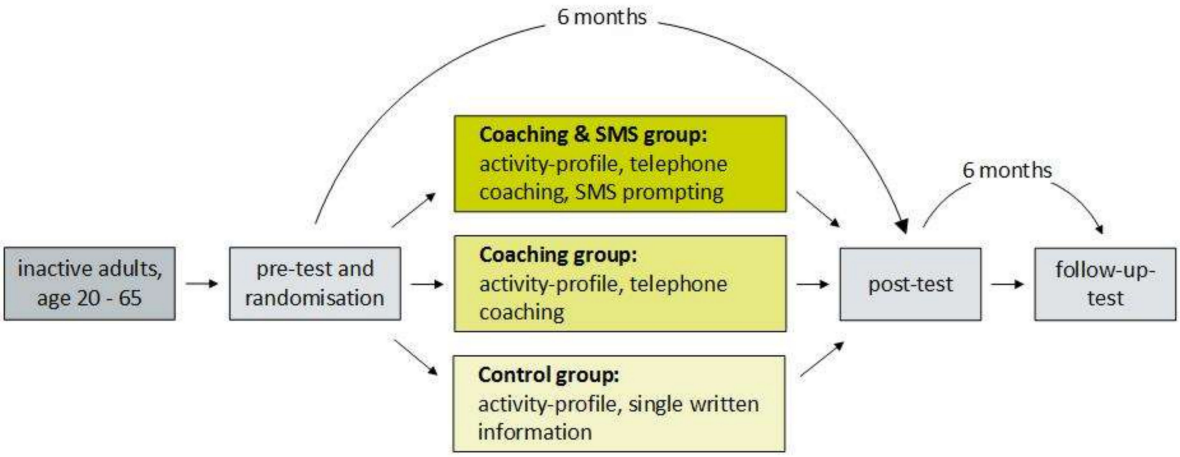

Figure 1. Study design. SMS: short message service.

2.2. Recruitment and Sample Size

Participants were recruited through newspaper advertisements, e-mail newsletters, advertisements provided by local and cantonal administration offices, companies' communications to employees, and flyers in pharmacies, medical practices, and physiotherapy clinics, as well as by word-of-mouth publicity. Individuals who were interested in participating contacted the study team

by e-mail or by phone. Eligible individuals were provided with a written informed consent before participating in the study.

Based on previous studies on remote PA promotion and the comparison of SMS prompts with alternative interventions [8,20] a small effect (d = 0.21) on self-reported PA was expected. Based on this expectation, a sample size calculation for an analysis of covariance (ANCOVA) including baseline PA as a covariate was computed [39]. In order to achieve a power of at least 80% (1-β error probability) and a significance level of 5%, a total of 242 participants were required. A subsequent total sample size of approximately 284 participants was needed after adjusting for an expected dropout rate of 15–20%.

2.3. Inclusion Criteria

Men and women between 20 and 65 years of age, who failed to meet the recommended 150 minutes of moderate PA [2] per week, were eligible for the study. Additionally, individuals had to understand German sufficiently in order to complete the study procedures. They also had to have residence in Switzerland. Inclusion criteria were checked using a questionnaire sent by e-mail. Physical activities of the previous week were assessed by an adapted version of the Simple Physical Activity Questionnaire (SIMPAQ [40]). Participants were further screened using the Physical Activity Readiness Questionnaire (PAR-Q [41]). Individuals who reported one or more health concerns in the PAR-Q were asked to consult their general practitioner (GP). If their GP approved moderate PA, individuals were deemed eligible. Individuals who reported more than 150 minutes of moderate PA or who shared the same household with another study participant were excluded. Further exclusion criteria were current pregnancy or a planned absence of more than 3 weeks during the next 6 months.

2.4. Group Allocation

A computer-based minimization procedure [42] stratified by age and sex was used to assign participants randomly to one of the three study arms. The randomization was conducted by a member of the research team, who was not involved in the intervention. In order to simplify the allocation of participants within the study team, randomization occurred prior to baseline data collection. Neither the study team nor the participant knew the group allocation prior to the start of the intervention.

2.5. Program Development

2.5.1. Theoretical Foundation

The intervention content (e.g., BCTs) and delivery modes (e.g., frequency and density of participant's contact) were defined according to the evidence of previous studies in the area of behavior change research and to theoretical considerations.

The Behavior Change Wheel (BCW) framework [43,44] serves as the theoretical background of the intervention. The BCW allows a holistic consideration of behavior change interventions and summarizes existing behavior change theories. It clarifies the intervention functions (e.g., incentivization, training), policy levels (e.g., regulation, service provision), and BCTs which can influence behaviors. The theoretical domains framework of the BCW summarizes psychosocial determinants (e.g., social influences, beliefs about capabilities, goals) that explain the occurrence of a behavior in the so-called theoretical domains [45]. Each theoretical domain is influenced by certain BCTs [45]. Consequently, the selection of BCTs can be conducted theoretically by considering the theoretical domains. In contrast to various behavior theories, the BCW framework does not explain causal relations between the theoretical domains. Therefore, the MoVo (acronym for motivation and volition) Process Model by Fuchs et al. [46] serves as the theoretical basis to explain PA specific causal relations of theoretical domains. The MoVo Process Model combines concepts of stage theories (motivational and volitional phases of behavior change) and continuous behavior modes (causal relations). It represents an adaption of the Health Action Process Approach (HAPA) by Schwarzer [47] for PA-related behavior change. Psychosocial determinants of the MoVo Process Model

are assessed as secondary outcomes (see Section 2.7.3) and used to tailor the intervention content individually (see Section 2.6.1).

2.5.2. Intervention Content

The Movingcall program communicates BCTs and knowledge based on exercise science. The goal is to increase PA gradually and to reach the recommended 150 minutes of moderate PA per week or more [2]. Ten BCTs that were proven to be effective in changing PA behavior according to previous meta-analyses were selected (see background) [22–24,26–31]. For the present selection of BCTs, meta-analyses that defined BCTs according to an older taxonomy [48,49] were translated to the current V1 taxonomy. The resulting ten BCTs are described in Table 1. These BCTs were delivered to all participants.

Table 1. Applied behavior change techniques.

BCT (V1 Number)	Definition
Goal setting (behavior) (1.1)	Set or agree on (a) behavioral goal(s) that leads to increased PA.
Problem solving (1.2)	Analyze, or prompt the person to analyze factors influencing PA and generate or select strategies to overcome barriers and/or increase facilitators.
Action planning (1.4)	Prompt detailed planning of PA (must include at least one of context, frequency, duration and intensity). Context may be environmental (physical or social) or internal (physical, emotional or cognitive).
Review of behavioral goal(s) (1.5)	Review PA goal(s) jointly with the person and consider modifying goal(s). This may lead to re-setting the same goal, a small change in that goal, or setting a new goal instead of (or in addition to) the first, or no change.
Feedback on behavior (2.2)	Give informative or evaluative feedback on monitored (including self-monitored) PA.
Self-monitoring of behavior (2.3)	Prompt self-monitoring and recording of PA (i.e., diary).
Social support (3.1)	Advise on, arrange or provide social support (e.g., from friends, relatives, colleagues, buddies or staff). This may include practical help (3.2) and emotional support (3.3).
Instruction on how to perform the behavior (4.1)	Teach skills and knowledge required for specific physical activities, i.e., give clear instructions.
Information about health consequences (5.1)	Provide information about health consequences of physical inactivity (PA).
Behavior practice/rehearsal (8.1)	Prompt practice or rehearsal of the PA one or more times in a context or at a time when the performance may not be necessary, in order to increase habit and skill.

Definitions derived from Michie et al. [21]. PA = physical activity. BCT = behavior change technique.

The Movingcall program allows for 25 additional BCTs (listed Table 2). This includes BCTs that might be implemented unintentionally within the conditions of a regular coaching session (e.g., set graded tasks, focus on past success) and BCTs with scarcer evidence of effectiveness in previous studies (e.g., prompts/cues, time management, social and self-reward [23,27]). Those BCTs are delivered according to the need of the participant. The inclusion of additional BCTs should ensure that all delivered BCTs are identified and documented.

All the BCT definitions and practical examples for PA promotion are gathered in an online manual. The online manual includes information on the optimal timing to deliver the BCT as well as information on what theoretical domains are mainly influenced by the BCT [50,51]. BCTs are explained according to the V1 taxonomy by Michie et al. [21]. To simplify documentation, the BCTs subcategories of *social support* (i.e., *unspecified*, *practical*, and *emotional*) are merged. Similarly, two BCTs of *natural consequences* (*salience of consequences* and *information about emotional consequences)* and four BCTs of *reward and threat (social reward, social incentive, self-incentive*, and *self-reward)* are merged. The BCTs *time management* and *provide information on where and when to perform* are defined according to CALO-RE taxonomy [48].

The Movingcall program further comprises exercise science based advice for previously inactive adults. This includes information on a reasonable initial regime and increasing endurance and resistance training with regard to frequency, duration and intensity (e.g., start with 30 minutes brisk

walking and increase to 45 minutes within the next three weeks). Further topics are the inclusion of PA in everyday life (e.g., plan walking distances, go to work by bike, balance training in the office), advice regarding balance training as well as stretching, and recommendations regarding movement or sports (e.g., interval training for Nordic walking). This information is gathered in our written guidelines.

Table 2. Optional behavior change techniques named and numbered according to Michie et al. [21].

Goal setting (outcome) (1.3)	
Discrepancy between current behavior and goal (1.6)	Habit reversal (8.4)
Review outcome goal(s) (1.7)	Generalization of target behavior (8.6)
Behavioral contract (1.8)	Graded tasks (8.7)
Time management (according to the 'Coventry,	Pros and cons (9.2)
Aberdeen & London – Refined' (CALO-RE) Taxonomy [48])	Reward and threat (summarizing 10.4, 10.5, 10.7, 10.9)
Self-monitoring of outcome(s) of behavior (2.4)	Restructuring the physical environment (12.1)
Feedback on outcome(s) of behavior (2.7)	Restructuring the social environment (12.2)
Provide information on consequences of behavior to the individual	Avoidance/reducing exposure to cues for the behavior (12.3)
(5.2 and 5.6 summarized)	Adding objects to the environment (12.5)
Provide info on where and when (According the CALO-RE	Framing/reframing (13.2)
Taxonomy [48])	Mental rehearsal of successful performance (15.2)
Demonstration of the behavior (6.1)	Focus on past success (15.3)
Prompts/cues (7.1)	Self-talk (15.4)
Habit formation (8.3)	

2.6. Intervention Delivery

2.6.1. Tailoring

Intervention content of all study arms is tailored individually to participants' preferences and needs. This includes tailoring on demographics (e.g., age, place of residence), on the current behavior (e.g., form of activities, amount of PA per week), and on theoretical domains that influence the behavior (e.g., social support). Furthermore, information about participants' intention, planning, pros and cons, self-efficacy, barriers, coping strategies, social support, knowledge on PA recommendation, PA behavior, personal goals and constraints, and current living conditions are used for tailoring. The required information is retrieved during the pre-test period. A focus is placed on BCTs that influence theoretical domains with the most potential for development. Depending on the study arm, the tailoring will be continued dynamically during the coaching process.

2.6.2. Activity Profile

Participants in all study arms (including the control group) have access to their personal activity-profile on an interactive homepage (www.movingcall.com; Figure 2) [52]. The platform is designed to enable and standardize the delivery of the BCTs *action planning* and *self-monitoring*. The password-protected profiles can be used as a stand-alone tool or can simplify the interaction between participant and coach. To actualize the coaching process, each coach has access to the profile of the corresponding participant. Within the profile physical activities are scheduled and documented on a "plan page". Activities can be selected from a database and entered into the participants' plan. In order to self-monitor the PA behavior, completed activities need to be checked and additional activities should be entered. Participants are encouraged to document all activities lasting 10 minutes or more. The homepage provides kilocalories (kcal) and the metabolic equivalent (MET) of entered PA according to the compendium [53]. The profile further includes a note board to simplify communication between coach and participant. Interaction with other participants is not possible. Lastly, the homepage includes an online questionnaire tool. Participants use their login to answer the questionnaires and the coaches can access to the answers. The use of the profile is explained to all participants by phone prior to the start of the intervention. Participants are given access to their profiles during the intervention and during the follow-up period.

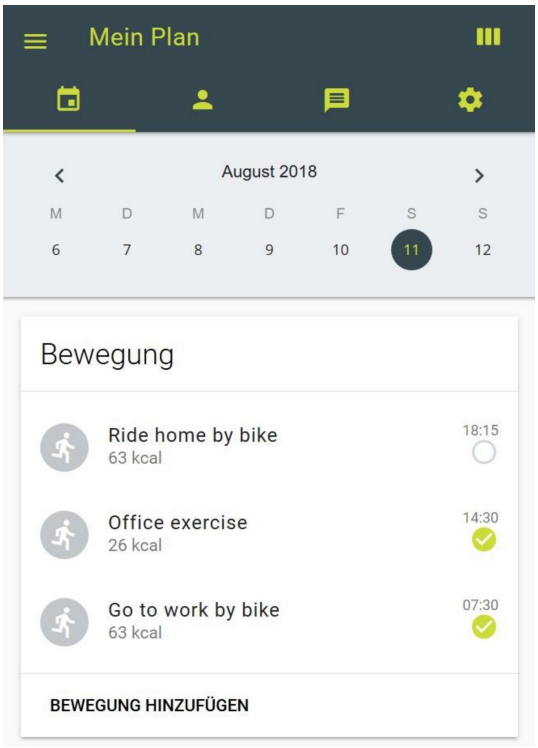

Figure 2. Plan page of activity profile on www.movingcall.com.

2.6.3. Telephone Coaching (Coaching Group)

Participants in the coaching group receive twelve biweekly telephone coaching sessions. Coaching sessions last 15–20 minutes during the course of the intervention and 30–40 minutes in the first two sessions. Participants are called by the same coach for the entire intervention period. If the biweekly rhythm is interrupted (e.g., due to vacations) or if participants miss a call, coaches can reschedule the session. Occasional variation of the biweekly rhythm between 1 and 3 weeks between each coaching session is considered normal. After each call the coaching session is summarized in a few sentences on the "note board" of the participant. Participants and coaches can leave remarks on the note board but it does not serve as a chat function.

The coaching refers to an interactive discussion between participant and coach. In accordance with the definition of health coaching by Olsen [11], the sessions are goal-oriented, client-centered, and focused on PA. Questions on nutrition or other health-related concerns as well as unrelated topics are not answered in detail. Coaches encourage their participants to build autonomy, self-confidence and self-efficacy and to gain knowledge and experiences concerning the benefits of PA.

All coaching sessions contain the elaboration of BCTs and advice on training concepts. The scope of each specific coaching session is stated in the written guidelines. During the first sessions, coaches focus on the development of a functional relationship and deliver information on the procedure of the coaching. Additionally, coaches start to encourage participants to set goals and to plan their physical activities. Established activity plans are inserted in the personal profile on the homepage and visible for participant and coach. With support of the coach, participants proceed to the following session by establishing coping strategies to overcome personal barriers. All main BCTs and additional BCTs are delivered as required in the 12 sessions. Based on the self-monitoring data which is visible on the profile and based on the discussion during the coaching sessions, participants receive feedback concerning their behavior change towards a physically active lifestyle. Towards the end of the 12 sessions, coaches focus on the maintenance of PA levels.

2.6.4. Telephone Coaching and SMS Prompting (Coaching and SMS Group)

Participants allocated to the coaching and SMS group receive the same telephone coaching as the coaching group. Additionally, participants in this group receive four SMS prompts during each two-week period (48 in total). The SMS are written, sent, and timed by the corresponding coach through an online platform. SMSs have the consignor of Movingcall and it is not possible to respond. Participants are asked if they have a preferred time (morning, noon, afternoon, evening) to receive the prompts. Within this time the SMSs are sent at variable time points. During each two-week period participants receive one SMS relating to PA knowledge, one relating to discussed BCTs, one containing a reminder, and one that consists of a feedback on documented physical activities (examples in Table 3). The language style and length of the SMSs are standardized and all SMSs are collected and saved.

Table 3. Example for text messages.

Topic	Example
Knowledge transfer	Dear Ruth, did you know that regular endurance exercise helps boost your immune system?
Feedback on performance	Hello Mr. Meier, based on your online entries, I have seen that you had an active weekend. Gardening and a long walk on Sunday, congratulations!
BCT	Dear Katy, take your time to think about what prevents you from using the bike to go to work. Let's discuss these obstacles next time☺. Have a good day.
Reminder	Good morning Ms. Bianchi, today is your first after-work swimming session. Don't forget to pack your swimwear and have fun! Regards

2.6.5. Intervention Provider

The coaching sessions are held by 28 trained sport science and psychology students. The training of the coaches consists of ten lectures and practical exercise for telephone coaching. Coaches are provided with an online handbook on BCTs and written guidelines. The following topics are included in the training: (1) The application of BCTs and the theory of behavior change; (2) An autonomy-supportive and client-centered coaching style; (3) Knowledge based on exercise and movement science to advice previously inactive adults; (4) The tailoring procedure; (5) Standardization of the intervention delivery (including written recommendation and SMSs); and (6) Data collection and documentation of the intervention. Each coach takes part in a one-hour know-how-check prior to the first coaching session, to ensure the coaching skills are sufficient. During the intervention delivery, current challenges in coaching situations are discussed and above listed topics are deepened in biweekly team meetings.

2.6.6. Intervention Documentation and Assessment of Adherence

Applied BCTs are documented and coded by the coaches after each coaching session. In addition, the duration, date and time of each session is recorded.

The adherence of participants to the intervention is assessed in two ways. First, the engagement of participants is assessed based on their personal profile. The amount of active edits of each participant within the personal profile is recorded (e.g., entering a planned PA). Second, the completeness of intervention delivery is assessed by documenting date, duration and number of attended coaching sessions. Thereby the subcategories "standard", "not standard", "non-usage attrition", and "dropout" are distinguished [54]. A total of 12 coaching sessions with up to two interruptions of maximum four weeks between two coaching sessions and an overall intervention duration of 22 (norm) to 26 weeks are considered as standard. Participants who stop the coaching (non-usage attrition) are asked for possible reasons and asked to still participate in the post and follow-up-tests. Individuals lost to post and follow-up-tests are considered as dropouts.

2.6.7. Minimal Intervention (Control Group)

Participants allocated to the minimal intervention group receive a single written recommendation about health-enhancing PA at the beginning of the intervention. The recommendation is tailored individually and covers information on all main BCTs. An exemplary PA plan and an explanation on how to adapt the plan is included. Participants in this group are asked to follow the recommendation, to self-monitor and plan their PA within their profile on the homepage and by doing so increase PA gradually during the intervention period. Recommendations are written by the coaches within a predefined template. Participants receive their recommendation as a PDF by e-mail and it is inserted on the note board within the personal profile. Participants in the minimal intervention group only have contact with the study team during data assessments.

2.7. Assessment of Primary and Secondary Outcomes

The assessment of primary and secondary outcomes is conducted without on-site presence of participants. Self-reported and objectively assessed PA level of one week, theoretical domains of PA as well as health and wellbeing-related variables are assessed in the pre, post and follow-up tests. After 3 months of intervention all participants are asked to answer a feedback questionnaire. Personal data and socio-demographic information are assessed during the inclusion procedure. Measures of all test periods are displayed in Table 4.

Table 4. Primary and secondary outcomes assessed in the Movingcall study.

Outcome Measure	Data Collection Instrument	Measure Point (Months)
Inclusion criteria	Adapted version of the Simple Physical Activity Questionnaire (SIMPAQ) [40]	0
Readiness for PA	Physical Activity Readiness Questionnaire (PAR-Q) [41]	0
Socio-demographic data	Commonly used items	0
Physical activity level	SIMPAQ [40] ActiGraph data of 7 days [55]	0, 6, 12 0, 6, 12
Variables used for tailoring	Self-compiled questionnaire on personal situation Self-compiled questionnaire on health restrictions, experience in PA and goals	0 0
Psychosocial determinants	Intention [56,57] Action planning [58] Outcome expectations [59] Self-efficacy [60]. Perceived barriers [46] Coping strategies [61] Social support [62] Self-concordance [63]. Knowledge about health enhancing PA and fitness rating [64–66]	0, 6, 12 0, 6, 12 0, 6, 12 0, 6, 12 0, 6, 12 0, 6, 12 0, 6, 12 0, 6, 12 0, 6, 12
Perceived stress-related exhaustion symptoms	Shirom–Melamed Burnout Measure (SMBM) [67]	0, 6, 12
Health-related quality of life	Short-Form 12 Questionnaire (SF-12) [68,69]	0, 6, 12
Feedback on aspects of the	Self-compiled questionnaire on satisfaction and homepage usability	3
Intervention	Self-compiled questionnaire on intervention depending on study arm	3, 6

2.7.1. Self-Reported Physical Activity

A structured telephone interview is carried out to assess participants' self-reported PA. This interview follows the questions described in the SIMPAQ (Simple Physical Activity Questionnaire) [40]. In the present study, self-reported PA serves as the primary outcome. The SIMPAQ refers to PA during the previous 7 days. Furthermore, the structured interview asks for the time spent in bed and the time spent with the activities "sitting or lying", "standing", "walking", and "other activities" (e.g., house work, gardening) for one of the usual days of the previous week. The duration and intensity of athletic training and recreational physical activities are assessed

separately for each day. SIMPAQ was validated with university students by Schilling et al. [70] and has shown a moderate to strong correlation to accelerometer data and to established self-report questionnaires (Seven-Day Physical Activity Recall [71] and the short form of the International Physical Activity Questionnaire [72]). Compared to other self-report questionnaires the SIMPAQ is less time consuming [70].

In the present study, the original version of the SIMPAQ interview is extended to assess moderate or vigorous activities in everyday life. The intensity of the time spent walking and the time spent with other activities is specified by the question "how much of this time did you walk/move with an intensity that leaves you slightly out of breath?" Additional questions are added to the interview to assess: (1) If the last week is considered "a normal week"; (2) Illnesses and injuries during the last week; (3) Illnesses and injuries during the past 6 months including days of occupational absences; (4) Regular medication; and (5) Body weight including the time point and the location of weighing. In the post and follow-up tests two more questions are added to assess: (6) Other health-related behavior change attempts (e.g., stop smoking); and (7) The attendance to other services that support PA-related behavior changes (e.g., physiotherapy).

Interviews are conducted by specifically trained members of the study team. They are never conducted by the coach of a participant and interviewers are unaware of the group allocation.

2.7.2. ActiGraph Data

PA of 1 week is objectively assessed with the ActiGraph wGT3X-BT. The triaxial accelerometer records intensity and duration of accelerations and converts the signals to "activity counts" [55]. Participants receive the device by post at the beginning of the pre-, post-, and follow-up assessment period. All participants are requested to wear the ActiGraph on the non-dominant wrist for 7 to 10 consecutive days and nights. Hip-worn accelerometers are regarded as superior for predicting locomotion and estimating energy expenditure [73]. However, estimates of moderate and vigorous PA of wrist- and hip-worn accelerometers are comparable [74]. While hip-worn accelerometers are today's standard, wrist-worn accelerometers have demonstrated higher wear-time compliance [74,75]. Wrist-worn assessment is therefore considered more feasible for the remote setting.

Each participant is called by the allocated coach to explain how to handle the ActiGraph and the procedures of the test period. Participants are asked to wear the device until the SIMPAQ interview that is arranged after the requested wear time. The ActiGraph should be ignored and only removed when swimming or in a sauna. Non-wear periods are reported on a sheet enclosed in the mail. A prepaid envelope is attached for returning the ActiGraph along with the sheet.

2.7.3. Psychosocial Determinants of PA and other Measures

Online questionnaires are used to assess additional secondary outcomes and information needed for individual tailoring. Questionnaires are programmed within the interactive homepage. A link to answer the questionnaires is sent to the participant by e-mail.

Applied instruments have previously been used in empirical research in German speaking countries. Except for self-composed items, acceptable validity and reliability have been demonstrated in previous studies (references listed below).

The following measures are assessed in the pre- post- and follow-up test-periods.

- **Intention**: Motivational readiness for PA-related behavior change is assessed according to the stages of change of the Transtheoretical Model [56,76]. Participants select one out of five answers to the question "Are you regularly physically active, this means at least 20 minutes on 3 days of the week?", e.g., "No, but I intend to become more physically active in the next 6 months". A single item to measure the strength of intention is added. Participants quantify their intention to be regularly physically active on a scale from zero (no intention) to five (very strong intention) [57,63].

- **Action planning** is measured by five items [61]. Participants are asked if they defined when, where, how, how often, and with whom they plan to exercise. For example "I have made a detailed plan regarding when to exercise". Answers are given on a Likert-scale from one (not true) to four (completely true).
- **Outcome expectations** regarding regular PA are assessed with 16 items validated by Fuchs [59]. Participants are asked to rate their expectations towards specific outcomes on a Likert-scale ranging from one (not true) to four (completely true). For example "If I were physically active on a regular basis, I would lose weight".
- **Self-efficacy** is assessed consistently with Fuchs [60] by three items. The confidence to begin, to maintain and to restart regular PA is measured on a six-point Likert-scale from one (No confidence) to four (100% confidence). For example, "I am confident that I could start with new physical activity".
- **Perceived barriers:** Participants are presented 19 potential barriers (e.g., "being tired") and asked to indicate how strong each one prevented PA on a Likert-scale from one (not at all) to four (very much) [46].
- **Coping strategies** on barriers are measured by five items applied and validated by Sniehotta et al. [58]. For example "I have made a detailed plan regarding what to do if something interferes with my plans". Responses are given on a four-point Likert-scale from one (not true) to four (completely true).
- **Social support** is assessed by seven items that rate the confidence for support of the social environment on a four-point Likert-scale from one (never) to four (always) [62]. For example, "I am confident that people of my social environment will be physically active with me".
- **Self-concordance** is measured by four items on the self-concordance scale. The scale was composed and validated by Seelig and Fuchs [63]. Participants are asked to rate their internal/external motivation on a Likert-scale ranging from one (completely false) to four (completely true). For example, "If I am physically active within the next weeks and months, this is because other people say I should".
- **Knowledge about health enhancing PA and fitness rating:** Participants are asked to rate their fitness level (on a scale from one to ten, one item) [64] and their level of health-enhancing PA ("Do you think you are sufficiently active for your health? Yes/No", one item) [65]. Knowledge of general PA recommendations are assessed by two items previously used by Gerber et al. [66].
- **Perceived stress-related exhaustion symptoms** are measured by the validated Shirom–Melamed Burnout Measure (SMBM) [67]. Three subscales (physical fatigue, emotional exhaustion and cognitive weariness) are assessed within 14 items.
- **Health-related quality of life:** The Short–Form 12 Questionnaire (SF-12) is used to assess health-related quality of life [68,69]. The questionnaire includes 12 items on general physical health status and mental health distress. The questionnaire's validity and reliability has been demonstrated by Craig et al. [36].

Two questionnaires are used to tailor the intervention content and are only applied in the pre-test. One questionnaire consists of family structure, living situation and workload in four self-compiled items. The other instrument assesses health restrictions, experience in PA and personal goals.

After 3 months each participant is invited to provide feedback on aspects of the intervention. The self-compiled questionnaire measures general satisfaction with the program, goal achievement, motivation to proceed and participant's opinion on possible program extensions (e.g., interaction with other participants). Participants are asked to rate the usability of the personal profile, to evaluate the value of BCT-based advice and to name the most important recommendation for them personally. The control group is asked to rate the written recommendation. In the coaching and the coaching and SMS group the quality of the relationship between participant and coach is assessed. In the coaching and SMS group, it is evaluated whether the SMSs are perceived as beneficial and what topic

is considered most motivating. Questions specific to group allocation are asked a second time in the post-test.

2.8. Data Processing and Statistical Analysis

ActiGraph data are analyzed using the ActiLife software (Version 6.13.3, ActiGraph, Pensacola, USA). Daily minutes of moderate-to-vigorous physical activity (MVPA) are computed after declaring sleep and non-wear time. Currently there are no widely used and validated cut-off-values to classify MVPA for adults' activity count of wrist-worn ActiGraph data. The cut-off values are therefore chosen on the basis of existing explorative analysis [77] and their comparison to cut-off points for children [78]. According to Kamada et al. [77] activity counts per minute are classified as sedentary activity 0–1999, light activity 2000–8249, and MVPA > 8249. The option "worn on the wrist" provided by the ActiLife software is not selected given its systematic underestimation of energy expenditure [79]. Sleep is determined using the Cole–Kripke algorithm [80]. Non-wear time is calculated according to Troiano [81]. Physical activities listed on the non-wear sheet (e.g., swimming) are added as moderate activities. In order to be analyzed, participants need to have a non-wear time of less than 10% [82]. At least four weekdays and one weekend day are required [55]. The first day of wear-time is not included. For further analysis, the mean of MVPA per day of all assessed valid days is computed.

All statistical analysis will be conducted as intention-to-treat. Group differences in primary and secondary outcomes will be calculated using linear mixed models. Linear mixed models will include intervention group, time, group × time interaction, and baseline measures as fixed effects and subjects as random effects. Statistical analysis will be conducted using the statistical software STATA (StataCorp, College Station, USA). Effect sizes for pre-post change scores and the corresponding confidence intervals will be provided [83,84].

3. Discussion

The present paper describes the rationale, design, and content of a randomized controlled trial on remote PA promotion. The evaluation of the three study arms will enable conclusions on effects of coaching and prompting. Telephone coaching [12] based on suitable BCTs [24] as well as SMS prompting [17] has been proven effective to induce PA-related behavior changes. However, so far only few studies compared multiple intervention concepts to elicit, which concept should be translated into practice. Van Wier et al. [85] concluded that lifestyle counselling by phone as well as by e-mail is an effective tool to reduce body weight in comparison to a control condition. Regarding PA behavior changes, only telephone coaching showed significant improvements compared to the control group. Another study by Marcus et al. [86] and one by van Keulen et al. [87] detected no difference in PA levels comparing tailored print to telephone communication for PA promotion. To our knowledge, text messages in combination with telephone counselling sessions have only been conducted in weight loss and disease management studies [88] and have proven effective. Further studies, using multiple intervention arms to compare short- and long-term efficacy of specific intervention concepts are required [38]. Thereby, the provision of a detailed description of intervention contents will help identify evidence-based practice [12].

The present study will expand previous research and contribute to an increased understanding of remote intervention components for PA promotion in working aged adults. We hypothesize that coaching combined with prompting results in a higher and more sustainable increase in PA than coaching alone. We further hypothesize that both coaching groups outperform the minimal intervention group. The analysis of psychosocial determinants of PA will contribute to the theoretical explanation of PA behavior change. The effect of BCT based coaching on specific psychosocial determinants can be explored. Thereby, the precise documentation of applied BCTs will be valuable to further specify the content of the coaching. The three time points of measurements will further allow conclusions on psychosocial determinants relevant for maintenance of PA levels. Finally, the analysis

of participants' engagement with the program as well as their feedback will enable to analyze the feasibility of remote PA promotion in Switzerland.

The following strengths and limitations of the study should be considered. First, it is essential that participants do not visit a clinical institution during the entire study. In Switzerland, the main barriers for PA are "lack of time" because of occupational or other duties (40%), "lack of motivation" (18%), and "medical reasons" (18%) [89]. One of the advantages of remote PA promotion is the absence of travel time. In order to reach the target group of physically inactive adults, the remote setting needed to be preserved in the study setting.

The second strength/limitation is the objective assessment of PA. Studies on PA promotion commonly use self-reported measures to assess PA [8]. To overcome social desirability and recall bias, PA is additionally assessed by ActiGraph. Given the remote setting of the present study, it is considered essential that the ActiGraph is easy to handle and can be explained by phone. The decision for a wrist-worn assessment will probably lead to higher wear-time of the devices [75]. It is however a clear limitation that no validated cut-off points exist for wrist-worn ActiGraph data. Additionally, the possibility to compare the data with studies using hip-worn measures will be limited. Third, the present study implements a minimal credible intervention instead of a traditional waiting list or control group. This is considered important for two reasons: First, behavioral interventions cannot be blinded to the condition a participant is in. The minimal credible intervention ("placebo group") is an acceptable possibility to overcome the bias of a control group [90,91]. Second, implemented intervention components have already proven effective in previous studies [8]. Therefore, the central objective is to compare their efficacy to a treatment that could be considered "treatment as usual". Our minimal intervention is considered comparable with simple online tailored information or advice from a GP.

4. Conclusions

With regard to the increasing cost of non-communicable diseases, agencies in the health sector are currently looking for attractive personalized and affordable approaches in order to help individuals adapt a healthy lifestyle. Internet-delivered interventions, as well as coaching and prompting, are promising approaches to reach adults in Switzerland. The present study will contribute to the knowledge on how to improve PA levels effectively and sustainably in adults. Further insights into effects of coaching, prompting and tailoring strategies based on utilizing suitable BCTs on PA promotion can be delivered.

Trial registration: ClinicalTrials.gov ID NCT02918578 registered on 23/09/2016.

Ethics Approval and Consent to Participate: The study protocol was approved by the ethics committee *Nordwest und Zentralschweiz*/EKNZ (ID: 2016-00560). The written consent of participants to participate was gathered prior to study inclusion.

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Chapter 4
Publication 2

Telephone-based coaching and prompting for physical activity: Short- and long-term findings of a randomized controlled trial (Movingcall)

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Telephone-Based Coaching and Prompting for Physical Activity: Short- and Long-Term Findings of a Randomized Controlled Trial (Movingcall)

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Abstract: This study analyzed the short- and long-term efficacy of telephone coaching and short message service (SMS) prompting for physical activity (PA) promotion. Two-hundred-and-eighty-eight adults (age: 42 ± 11 years) were assigned randomly to three intervention arms: The intervention groups received 12 bi-weekly telephone calls with (coaching and SMS group) or without (coaching group) additional SMS prompts (n = 48 SMS). The control group received a single written PA recommendation. Self-reported and objective moderate-to-vigorous physical activity (MVPA) levels were assessed by a structured interview and by accelerometer at baseline, after the intervention (6 months), as well as after a no-contact follow-up (12 months). At post-test, self-reported MVPA increased by 173 min/week (95% CI 95 to 252) in the coaching group and by 165 min/week (95% CI 84 to 246) in the coaching and SMS group compared to control. These group differences remained similar in the follow-up test. For the objectively assessed MVPA, the coaching group increased by 32 min/week (95% CI 0.1 to 63) and the coaching and SMS group by 34 min/week (95% CI 1.6 to 66) compared to the control group. In the follow-up test, the objective MVPA levels of the intervention groups no longer differed from baseline, but group differences persisted as the control group decreased below baseline. Additional SMS prompts did not result in a further increase in PA. Telephone coaching can be considered an effective tool for PA promotion.

Keywords: physical activity promotion; remote; telephone coaching; SMS prompting; inactive adults

1. Introduction

Physical inactivity is considered a major public health problem [1,2]. One-third of the Swiss as well as the world's population does not reach the recommended minimum of 150 min of moderate-to-vigorous physical activity (MVPA) per week [3–5]. Main barriers for physical activity (PA) in working adults are lack of time, lack of motivation, long working hours or health reasons [3,6]. Resulting inactivity is associated with a higher prevalence of non-communicable diseases including cardio-vascular diseases, type 2 diabetes, some cancers or depression [1]. Given the increasing cost of non-communicable diseases [7,8], effective PA promotion programs designed to help individuals reach a physically active lifestyle are needed.

Individually tailored interventions and programs that apply essential behavior change techniques (BCTs) were found to be effective at improving PA behavior [9,10]. Existing reviews underline the importance of self-monitoring, goal setting, action planning, social support, problem solving, and feedback on performance as key components of behavioral change [11–15]. On an individual level,

interventions were traditionally delivered in face-to-face settings [16]. In order to reach a broader public, low-threshold interventions delivered by phone or internet have been increasingly investigated in the last two decades [10,17]. Compared to face-to-face interventions, these communication modes were found to be more cost effective [18]. Telephone coaching is particularly promising as it enables a remote but personal relation and repeated contacts to promote behavior change [10,19,20]. Short message service (SMS) based prompts require less financial and personal expenses compared to coaching and have been shown to result in small-to-moderate positive effects in preventive health behaviors [21]. Web-based interventions can be delivered to the largest number of people; however, high dropout and non-usage attrition are commonly observed when implementing such interventions [17,22]. Described intervention components showed small-to-moderate positive effects on self-reported PA levels in the short-term. The maintenance effects of PA promotion are less evident and objective measures of PA less examined. Additionally, it remains unknown which intervention components are most effective and can best be translated successfully into practice. Studies with multiple intervention arms that compare the efficacy and applicability of different intervention components are needed [23].

The present study investigated three different versions of a PA promotion program consisting of evidence based BCTs [24]. The short- and long-term efficacy of telephone coaching and SMS prompting for PA promotion were analyzed using self-reported and objectively assessed PA measures. It was built upon the hypothesis that the combination of telephone coaching and SMS prompting would result in a greater and more sustainable increase in PA compared to coaching alone and that both coaching conditions would show higher PA levels compared to a control group with minimal intervention. The present study focused on outcomes of PA (assessed at baseline, post-test, and follow-up test) as well as intervention engagement and acceptance.

2. Methods

2.1. Study Design and Participants

A three-armed randomized controlled trial with an intervention lasting six months and a follow-up period of an additional six months was conducted. The entire study was conducted without face-to-face contact with participants. A detailed description of the rationale for the study protocol and the development of the intervention can be found in a previous publication of the study protocol [24]. The randomized controlled trial was approved by the ethics committee of Northwestern and Central Switzerland (EKNZ; ID: 2016-00560) and was registered on ClinicalTrials.gov (ID: NCT02918578).

Woman and men aged 20 to 65 years achieving less than 150 min/week of MVPA [5] were eligible for the study. Self-reported PA levels achieved during one week were assessed in a screening questionnaire delivered by e-mail [25]. Participants achieving less than 150 min of PA in the screening questionnaire but more than 150 min in the baseline assessment were still included in the study. Further inclusion criteria were sufficient German language skills and a residency in Switzerland. Pregnant woman and individuals with an anticipated absence for more than three weeks during the intervention period were excluded. All participants were asked to complete the Physical Activity Readiness Questionnaire [26] to determine any potential risk factors for being physically active. Individuals with health concerns identified as a risk factor were only included in the study if their general practitioner approved their participation. Participants were recruited from August 2016 to October 2017 through flyers, newspaper advertisement, e-mail newsletters, internal advertisement, and by word-of-mouth publicity.

The minimal sample size was estimated based on the efficacy of previous studies on PA promotion and SMS prompting for self-reported PA [10,21]. A sample size calculation for an analysis of covariance with three groups including baseline PA as a covariate was computed [27]. Results showed that 242 participants were needed for a planned statistical power of 80%, a significance level of 5%, and an expected small effect size (d = 0.21) for between group differences. Adjusting for an expected dropout rate of 15–20%, a final number of 284 participants was computed [24].

2.2. Intervention

The three intervention arms differed in terms of the delivery mode but were based on the same intervention content. All participants received advice on training concepts and information on how to apply BCTs in order to increase PA. Ten BCTs that were found to be effective in previous meta-analyses were communicated to all participants. This included goal setting (behavior), problem solving, action planning, review of behavioral goal(s), feedback on behavior, self-monitoring of behavior, social support, instruction on how to perform the behavior, information about health consequences, and behavior practice/rehearsal [28]. Intervention content of all study arms was individually tailored based on demographics, personal goals, and experiences [24]. In addition to the above mentioned BCTs, 25 optional BCTs (e.g., habit formation, restructuring the physical/social environment) were applied according to the participants' needs [24]. The theoretical background of the intervention was provided by the Behavior Change Wheel Framework [29,30] and the MoVo (motivation and volition) Process Model by Fuchs et al. [31].

All participants (including the control group) had access to a password protected online platform (activity profile; http://www.movingcall.com) for planning and self-monitoring of PA [32]. Depending on the study arm, the platform was used as standalone tool or to enable interaction between participant and coach, in which case coaches had access to their participant's profiles to engage in the designed coaching program.

Randomization to one of the three study arms was conducted by a researcher who was not involved in the intervention. A computer-based minimization procedure stratified by age and sex was applied [33].

2.2.1. Coaching Group

Participants in the coaching groups received 12 bi-weekly telephone calls. The calls had a planned duration of approximately 20 min and were conducted by the same coach over the entire intervention period. The coaching facilitated a client-centered, goal-oriented discussion between participant and coach [34]. Each coaching session contained the use of BCTs. Participants were asked to set and adapt goals, to plan their PA behavior, to analyze and overcome barriers and to gradually habituate to a physically active lifestyle. Twenty-nine exercise science and psychology students provided the coaching. Each coach completed a three-month training course, completed by a know-how-test in which knowledge of the intervention content and coaching procedure were assessed. During the intervention, coaches attended bi-weekly team meetings to elaborate on the learned content and to discuss the coaching procedure.

2.2.2. Coaching and SMS Group

The coaching and SMS group received the same coaching regimen as the coaching group. Additionally, participants received four individually tailored SMS prompts during each two-week period (48 in total). Prompts were sent at varying times and there was no possibility to respond. The SMS prompts either contained information to discussed BCTs, feedback, PA knowledge or a reminder.

2.2.3. Control Group (Minimal Intervention)

The minimal credible intervention of the control group consisted of a single written recommendation at the beginning of the intervention. The advice contained tailored information on how to apply BCTs in order to increase PA. An exemplary plan on weekly PA was provided within the personal profile on the online platform. Participants of the control group were asked to follow the recommendation, to adapt their personal plan, and to self-monitor their PA behavior. With the exception of the assessment periods, participants of the control group did not have contact with the study team.

2.3. Outcome Measures

Outcome measures were assessed at recruitment (baseline), after the intervention (post-test, after six months), and after the follow-up period (follow-up test, after twelve months). Each test period consisted of a telephone interview, objective assessment of PA by accelerometer, and online questionnaires. Additionally, participants were asked to answer a questionnaire focused on feedback and acceptance in the middle of the intervention (three months). None of the assessments required on-site presence. Interviews and data processing were conducted blinded to group allocation.

2.3.1. Self-Reported Physical Activity

A structured telephone interview based on the Simple Physical Activity Questionnaire (SIMPAQ) was used to assess self-reported PA [25]. The interview assessed participants' time spent on specific activities during the last seven days (lying, sitting, standing, other activities, walking, and sports). In addition to the original interview, participants were asked about time spent in at least moderate intensity "walking" and "other activities". These two answers and the time spent on specific moderate-to-vigorous activities add up to the total MVPA per week.

2.3.2. Objectively Assessed Physical Activity

A wrist worn triaxial accelerometer (ActiGraph wGT3X-BT; ActiGraph, Pensacola, FL, USA) was used to objectively assess PA. ActiGraphs were mailed by post and procedures were explained by phone. Participants were instructed to wear the device for seven to ten consecutive days and nights (except for swimming or bathing), called wear time. The SIMPAQ interview was arranged at the end of the requested wear time to achieve matching assessment periods. ActiGraphs do not have a display and, accordingly, do not give any direct feedback while the participant wears it. Participants were asked to note and describe the non-wear time in a standardized document and otherwise to not let the device influence their regular behavior.

ActiGraph data were downloaded and analyzed using ActiLife version 6.13.2 (ActiGraph, Pensacola, FL, USA). ActiGraph counts were calculated using 3 axes (vector magnitude) and an epoch length of 60 s [35]. The suggested algorithm of ActiLife for wrist-worn data was not used, as it has shown to overestimate MVPA [36]. Explorative studies suggest cut off values for wrist-worn ActiGraph counts that result in similar amounts of MVPA than widely used cut off values for hip-worn ActiGraph counts [37]. According to Kamada et al. [37], accelerations with 0–1999 counts/min were coded as sedentary activities, 2000–8249 counts/min as light and accelerations, and above 8249 counts/min moderate-to-vigorous activities. Measurements were considered valid if there were at least four weekdays and one weekend day with a minimal wear time of ten hours per day [38]. Sleep time was detected using the Cole–Kripke algorithm and declared as non-wear time [39]. Wear time during the day was validated according to the algorithm of Troiano [40]. Non-wear time was then compared to participants' notes on their non-wear-time sheet. If participants reported MVPA during their non-wear-time (e.g., swimming) these minutes of activity were added to the count-based activities and non-wear-time was adapted. Intensities of described activities were classified as moderate according to the compendium [41]. Weekly count-based MVPA was computed based on the average of all valid days per person.

2.3.3. Perceived Physical Fitness

Perceived physical fitness was assessed by a 1 item proxy measure in the online questionnaire. Participants were asked to rate their current physical fitness level on a scale form one to ten [42].

2.3.4. Intervention Fidelity and Acceptance

Participant's adherence to the intervention was assessed in two ways. First, the completeness of the intervention delivery was categorized and evaluated. Interventions were rated as "standard", "not

standard" (incomplete intervention or interruptions of more than three weeks), "non-usage attrition" (withdrawal from intervention but participation in assessments), and "dropout" (withdrawal from study). Reasons for non-usage attrition or dropout were recorded.

Second, the engagement of participants with their activity profile was quantified by the number of active edits per months. Active edits refer to changes made within the activity profile, e.g., planning an activity on a specific day or self-monitoring (check) a completed activity.

Intervention content and completeness of delivery was documented by the coaches. Date, duration, and applied BCTs of each coaching session as well as reasons for non-executed coaching were recorded. Additionally, participants were asked about personal engagement and their perception of intervention implementation within the online questionnaire. Participants of the control group were asked how many times they read the recommendation and how they perceived the content. Participants in the coaching group were asked if the coaching was conducted regularly, how the relationship to the coach was perceived, and if the duration and frequency of calls were appropriate. Participants of the coaching and SMS group were additionally asked to rate supportiveness, as well as the content and frequency of the SMS prompts. In addition, all participants were asked questions on general satisfaction with the intervention after three months and in the post-test.

2.4. Data Analysis

Intention-to-treat analyses were applied to all datasets. Available data of participants completing the intervention as planned, not as planned or who withdrew participation (non-usage attrition) but completed the assessments, were analyzed in the study arm to which they were randomized. There were no data available for 13% of participants who were lost to follow-up. Participants were excluded from the analysis if they completed the assessments even though they: (a) were severely ill or injured during the entire week (5 participants in post-test and 5 in the follow-up test) and (b) if they were on sports vacation for the entire week (one participant in post-test). Unusual assessment weeks or illnesses/vacations lasting less than five full days were considered as normal variation, hence, the data were included in the analysis.

Population characteristics are presented for each intervention arm using means and standard deviations (SD) for continuous variables, as well as counts and percentages for categorical variables. Unadjusted means and boot strapped bias-corrected, accelerated confidence intervals of self-reported and objectively assessed MVPA are shown graphically for baseline, post, and follow-up measures.

Between-group change scores (baseline to post-test and baseline to follow-up test) of self-reported and objectively assessed MVPA as well as self-reported fitness levels were assessed using linear mixed models. Group, time, and the interaction effects between groups and time were included as fixed effects. Baseline measures were added as covariates and subjects as random effects accounting for between-subject heterogeneity. Potential confounders (gender, age, BMI, education, current health complaints, how ordinary the assessed week was) were included in the models as sensitivity analysis. The models were fitted using maximum likelihood estimation. Adjusted means for within group changes and among group differences in changes from baseline to post and follow-up-test are presented with 95% confidence intervals (CIs).

Between group differences in intervention completeness were assessed using the chi-square test. Average use of the web application was compared among groups using ANOVA. All statistical analyses were computed using the STATA version 15.0 (StataCorp, College Station, TX, USA).

3. Results

Table 1 displays sociodemographic data of all participants at baseline. Figure 1 displays the CONSORT flow diagram of the study. Summary statistics of self-reported and count-based minutes of MVPA per week are illustrated in Figure 2.

Table 1. Sociodemographic characteristic of the study population.

Variable	Control (n = 96)	Coaching (n = 99)	Coaching and SMS (n = 93)	Total (n = 288)
Age in years, mean (SD)	42.20 (11.39)	41.93 (11.12)	42.54 (11.78)	42.22 (11.39)
Age category, *n* (%)				
20–31 years	19 (19.8)	22 (22.2)	21 (22.6)	62 (21.5)
32–42 years	31 (32.3)	23 (23.2)	24 (25.8)	78 (27.1)
43–53 years	27 (28.2)	39 (39.4)	32 (34.4)	98 (34.0)
54–65 years	19 (19.8)	15 (15.2)	16 (17.2)	50 (17.4)
Gender, *n* (%)				
Female	64 (66.7)	69 (69.7)	64 (68.8)	197 (68.4)
Male	32 (33.3)	30 (30.3)	29 (31.2)	91 (31.6)
BMI in kg/m^2, mean (SD)	26.43 (5.33)	25.26 (4.28)	26.24 (4.99)	25.97 (4.89)
BMI Category, *n* (%)				
Underweight (<18.50)	2 (2.1)	2 (2.0)	1 (1.1)	5 (1.7)
Normal weight (18.50–24.99)	44 (45.8)	54 (54.6)	43 (46.2)	141 (49.0)
Overweight (25.00–29.99)	28 (29.2)	27 (27.3)	32 (34.4)	87 (30.2)
Obese (≥30.00)	22 (22.9)	16 (16.2)	17 (18.3)	55 (19.1)
Occupation, *n* (%)				
Employed	83 (86.5)	84 (84.9)	76 (81.7)	243 (84.4)
Student	4 (4.2)	8 (8.1)	8 (8.6)	20 (6.9)
House wife/husband	4 (4.2)	2 (2.0)	5 (5.4)	11 (3.8)
Pensioner	2 (2.1)	3 (3.0)	1 (1.1)	6 (2.1)
Unemployed	1 (1.0)	-	3 (3.2)	4 (1.4)
No response	2 (2.1)	2 (2.0)	-	4 (1.4)
Highest education level, *n* (%)				
Compulsory education	1 (1.0)	1 (1.0)	2 (2.2)	4 (1.4)
Apprenticeship	28 (29.2)	30 (30.3)	27 (29.0)	85 (29.5)
High school	21 (21.9)	21 (21.2)	22 (23.7)	64 (22.2)
University	39 (40.6)	39 (39.4)	37 (39.8)	115 (39.9)
Doctorate	5 (5.2)	7 (7.1)	5 (5.4)	17 (5.9)
No response	2 (2.1)	1 (1.0)	-	3 (1.0)
Yearly household income, *n* (%)				
<50,000 CHF	13 (13.5)	19 (19.2)	11 (11.8)	43 (14.9)
50,000–100,000 CHF	40 (41.7)	42 (42.4)	47 (50.5)	129 (44.8)
>100,000 CHF	41 (42.7)	35 (35.4)	32 (34.4)	108 (37.5)
No response	2 (2.1)	3 (3.0)	3 (3.23)	8 (2.8)
Family status: Number of children bellow 18 years, *n* (%)				
No children	69 (71.9)	63 (63.6)	63 (67.7)	195 (67.7)
1 child	9 (9.4)	8 (8.1)	9 (9.7)	26 (9.0)
2 children	10 (10.4)	19 (19.2)	12 (12.9)	41 (14.2)
3–4 children	3 (3.1)	3 (3.0)	1 (1.1)	7 (2.4)
Missing response	5 (5.2)	6 (6.1)	8 (8.6)	19 (6.6)

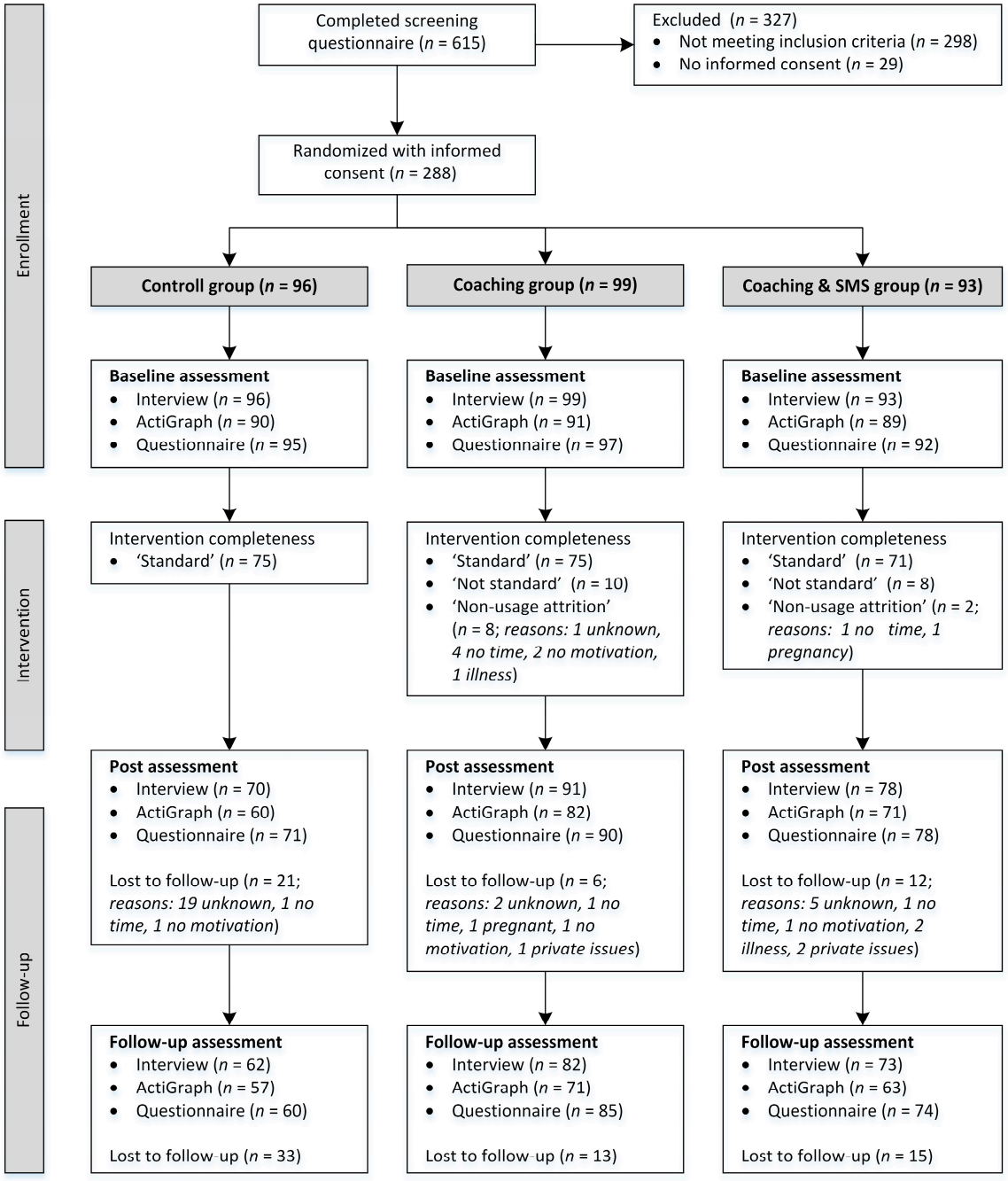

Figure 1. Flow diagram of the study.

Table 2 presents baseline adjusted changes in self-reported minutes of MVPA and differences among groups at each time point. Levels of self-reported MVPA increased in all three study arms. In the post and the follow-up tests, increases in self-reported minutes of MVPA per week were greater in the coaching and in the coaching and SMS groups compared to the control group. Means and CIs of the coaching and the coaching and SMS groups were very similar in the post and follow-up tests. Change scores of self-reported MVPA in the post and follow-up tests were similar, indicating that increases in MVPA were maintained after the end of the intervention.

Table 1. Sociodemographic characteristic of the study population.

Variable	Control (n = 96)	Coaching (n = 99)	Coaching and SMS (n = 93)	Total (n = 288)
Age in years, mean (SD)	42.20 (11.39)	41.93 (11.12)	42.54 (11.78)	42.22 (11.39)
Age category, n (%)				
20–31 years	19 (19.8)	22 (22.2)	21 (22.6)	62 (21.5)
32–42 years	31 (32.3)	23 (23.2)	24 (25.8)	78 (27.1)
43–53 years	27 (28.2)	39 (39.4)	32 (34.4)	98 (34.0)
54–65 years	19 (19.8)	15 (15.2)	16 (17.2)	50 (17.4)
Gender, n (%)				
Female	64 (66.7)	69 (69.7)	64 (68.8)	197 (68.4)
Male	32 (33.3)	30 (30.3)	29 (31.2)	91 (31.6)

1 child	9 (9.4)	8 (8.1)	9 (9.7)	26 (9.0)
2 children	10 (10.4)	19 (19.2)	12 (12.9)	41 (14.2)
3–4 children	3 (3.1)	3 (3.0)	1 (1.1)	7 (2.4)
Missing response	5 (5.2)	6 (6.1)	8 (8.6)	19 (6.6)

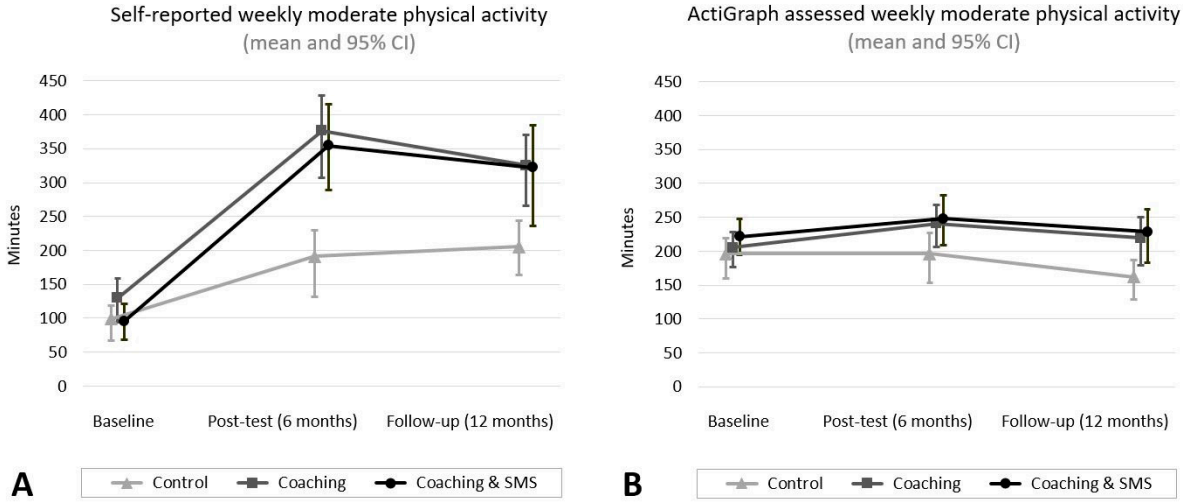

Figure 2. Unadjusted means and boot-strapped, bias-corrected, accelerated confidence intervals of moderate-to-vigorous physical activity (minutes/week) by intervention group. (**A**): Self-reported physical activity (baseline: n = 288, post-test: n = 239, follow-up test: n = 217) and (**B**): count-based physical activity (baseline: n = 270, post-test: n = 213, follow-up test: n = 191). SMS = Short message service.

Figure 2. Unadjusted means and boot-strapped, bias-corrected, accelerated confidence intervals of moderate-to-vigorous physical activity (minutes/week) by intervention group. (**A**): Self-reported physical activity (baseline: n = 288, post-test: n = 239, follow-up test: n = 217) and (**B**): count-based physical activity (baseline: n = 270, post-test: n = 213, follow-up test: n = 191). SMS = Short message service.

Table 2. Adjusted changes in self-reported minutes MVPA (moderate-to-vigorous physical activity) within groups and differences among groups at each time point.

M	Adjusted Mean Change from Baseline in min/week (95% CI)			Pairwise Comparison: Differences among Groups in Change from Baseline (95% CI)		
	Control	Coaching	Coaching and SMS	Coaching versus Control	Coaching and SMS versus Control	Coaching and SMS versus Coaching
6	86.9 (28.1 to 145.7)	259.9 (208.1 to 311.7)	252.3 (196.5 to 308.1)	173.0 (94.5 to 251.5)	165.4 (84.4 to 246.3)	−7.6 (−83.9 to 68.7)
12	98.9 (36.8 to 161.1)	211.4 (157.0 to 265.7)	212.1 (154.6 to 269.6)	112.4 (29.7 to 195.2)	113.2 (28.6 to 197.8)	40.9 (−37.2 to 119.0)

M = Months.

Changes in objectively assessed minutes of MVPA per week and differences among groups are shown in Table 3. The average wear time of the ActiGraph was eight days (baseline: M = 8.5 d, SD = 1.3; post: M = 8.3 d, SD = 1.6; follow-up: M = 7.0 d, SD = 1.4). Objectively assessed MVPA min/week increased in the post-tests for the coaching and coaching and SMS groups but not in the control group. In the follow-up tests, the levels of MVPA in the two intervention groups no longer differed from baseline levels, but were higher than in the control group. The objectively assessed MVPA of the control group declined below baseline in the follow-up test. In the direct group comparison, change scores in objectively assessed MVPA for the two intervention groups were higher compared to the control group in the post and follow-up tests. Change scores for the coaching and the coaching and SMS groups were similar at both time points.

Perceived fitness increased in all study arms. The two intervention groups reported a greater increase in perceived fitness at both time points compared to the control group. Increases in perceived fitness were similar in the coaching and the coaching and SMS groups. Within groups, change scores at post and follow-up tests were similar. Summary statistics of perceived fitness as well as baseline adjusted change scores and among group differences can be found in Supplementary Materials S1.

Table 3. Adjusted changes in count-based minutes of MVPA within groups and differences among groups at each time point.

M	Adjusted Mean Change from Baseline in min/week (95% CI)			Pairwise Comparison: Differences among Groups in Change from Baseline (95% CI)		
	Control	Coaching	Coaching and SMS	Coaching vs. Control	Coaching and SMS vs. Control	Coaching and SMS vs. Coaching
6	−5.1 (−28.7 to 18.6)	26.5 (5.8 to 47.1)	28.5 (7.0 to 50.0)	31.5 (0.1 to 62.9)	33.5 (1.6 to 65.5)	2.0 (−27.8 to 31.8)
12	−26.1 (−50.1 to −2.1)	6.9 (−14.7 to 28.5)	15.6 (−6.8 to 38.0)	33.0 (0.7 to 65.2)	41.7 (8.9 to 74.5)	8.7 (−22.4 to 39.8)

M = Months.

Adherence, Intervention Fidelity, and Acceptance

Intervention completeness (standard, not standard, non-usage-attrition, and lost to follow-up) differed among the three study arms ($Chi^2 < 0.001$). Overall seventy-seven percent of all randomized participants completed the intervention as planned. Thirteen percent of participants were classified as lost to follow-up in the post-tests and 21% in the follow-up tests. Participants who were lost to follow-up in the post-tests were also lost to follow-up in the follow-up tests. Dropout at post-test decreased from control (20%) over coaching and SMS (13%) to the coaching group (6%). Participants classified as lost to follow-up did not differ from other participants in terms of sociodemographic characteristics and baseline physical activity level. "Non-usage attrition" was higher in the coaching group (8%) compared to the coaching and SMS group (2%). Ten percent of participants in the coaching group and 9% in the coaching and SMS group were declared as "not standard" because of longer interruptions ($n = 13$) or not accomplishing all coaching sessions ($n = 5, 3 \times 11, 1 \times 10, 1 \times 9$ coaching). Reasons for dropout and extent of intervention completeness for each intervention arm can be seen in the flow diagram (Figure 1).

The average duration of the intervention was 22.6 weeks (SD = 1.4; range 20 to 27) for interventions rated as "standard". Interventions rated as "not standard" lasted on average 26.8 weeks (SD = 2.6; range 24 to 32). The follow-up assessment started on average 26.7 weeks (SD = 1.7; range 22 to 36) after the end of the intervention.

The frequency of application of the most often applied BCTs are listed in Table 4. The coaching calls lasted longer during the first (38 min, SD = 10.8) and the second (28 min, SD = 10.3) calls. The average duration of the third through to the twelfth call was 18.7 min (SD = 5.9). The use of the activity platform was higher in the coaching (median: 16.4 edits/month) and the coaching and SMS groups (19.2 edits/month) compared to the control group (2.6 edits/months). During the follow-up period, the median number of active edits per month dropped to zero in all groups. Ratings on the user friendliness of the activity profiles can be found in Supplementary Materials S2.

Eighty-five percent of the participants in the control group self-reported that they read the written recommendation between one and three times. The majority (89%) considered the recommendation being comprehensive or rather comprehensive. Descriptive statistics on participants' perception of the intervention per study arm as well as participants general acceptance can be found in Supplementary Materials S2.

Participants of the coaching and coaching and SMS groups reported that the coaching calls took place regularly (93%) or rather regularly (7%). The duration (97%) and the intervals among (93%) the calls were rated as fitting. Eighty-three percent of participants rated their relationship to their coach as trusting. In the coaching and SMS group, 90% of participants reported that they always received four messages among the coaching sessions. Messages were perceived as supportive (54%) or rather supportive (32%) and the frequency was rated as fitting (83%).

In the post-test, 82% of the participants from the coaching and SMS group, 86% from the coaching group, and 19% from the control group reported that they were satisfied or rather satisfied with

the intervention. Accordingly, 80% of participants in the intervention groups and 13% from the control group responded that the program did help or rather helped them to reach their personal PA-related goals.

Table 4. Frequency of application of used behavior change techniques.

Behavior Change Technique	Mean	SD
Action planning	7.2	3.2
Feedback on behavior	7	3
Self-monitoring of behavior	6.3	3.1
Problem solving	5.2	2.4
Goal setting (behavior)	4.7	2.6
Review of behavioral goal (s)	4.5	2.8
Instruction on how to perform the behavior	3	2.4
Social support	2.9	2.4
Habit formation	2.9	2.6
Information about health consequences	2.1	1.6
Goal setting (outcome)	1.6	2
Behavior practice/rehearsal	1.3	1.5

Mean and standard deviation (SD) of frequency of application per person over the 12 coaching sessions.

4. Discussion

This randomized controlled trial examined the efficacy of telephone coaching and SMS prompting for PA promotion in adults aged 20 to 65 years. Short-term changes in PA, maintenance of PA levels as well as acceptance of the interventions were analyzed and compared to a control group receiving a minimal credible intervention.

4.1. Changes in Physical Activity

Telephone coaching led to higher MVPA levels in the short- and the long-term compared to a single written recommendation. Self-reported MVPA of the coaching group increased by 173 min/week at the post-test and by 112 min/week at the follow-up test compared to the control group. Similar results were achieved in the coaching and SMS group, where increases in MVPA were 165 and 113 min/week higher at post and follow-up test, respectively. The SMS prompting did not lead to a further increase in MVPA compared to coaching alone. Changes in perceived fitness were comparable to the ones observed in self-reported PA: perceived fitness increased in all study arms, although participants of the two intervention groups showed a greater increase in perceived fitness compared to the control group. All groups persistently perceived their fitness level as higher after the non-contact follow-up.

In objectively assessed MVPA, only the two intervention groups showed an increase in MVPA from baseline to post-test. The coaching group increased its MVPA by 32 min/week and the coaching and SMS group by 34 min/week compared to the control group. This increase in wrist acceleration was not maintained over time: after the no-contact follow-up, objectively assessed MVPA levels of the two intervention groups were similar to baseline MVPA. Objectively assessed MVPA of the control group remained unchanged from baseline to post-test but decreased on average by 26 min/week in the follow-up test. The two intervention groups were, therefore, similarly more active compared to the control group at the post and the follow-up tests.

Observed increases in self-reported MVPA clearly contributed to participants meeting MVPA guidelines [5]. As previous studies have documented, a 15 min increase in self-reported PA per day can lead to a 4% reduction of all-cause mortality [43]. Presented increases in self-reported PA levels as well as group differences between the control and the intervention groups can, therefore, be considered highly relevant. Observed effects of the intervention on self-reported PA can be considered sustainable

as MVPA levels were maintained after the end of the intervention. However, maintenance effects of the intervention need to be interpreted cautiously, as objective PA returned to baseline.

Our findings confirm and extend existing research. Short-term increases in self-reported PA level following telephone-based PA promotion are well documented [19,20], but evidence of long-term effects are lacking [44,45]. This also applies to interventions concerning health coaching. In a recent review by Dejonghe et al. [46], only six out of the 14 included studies showed long-term efficacy. In this regard, the present study supports the findings on sustainable increases in self-reported physical activity levels. Concerning objectively assessed PA levels, there are very few studies that analyzed the short- as well as long-term effects of remote PA promotion [10,47]. One study by Van Hoecke et al. [48] compared different counseling strategies for PA promotion in older adults. Participants of an individually tailored coaching intervention as well as participants of a one-contact walking program showed larger increases in PA compared to a one-contact referral group. In accordance with the present study, self-reported PA was maintained after a no-contact follow-up, whereas objectively assessed steps (pedometer) decreased. The fact that objectively assessed PA shows smaller effects compared to self-reports has been observed in multiple studies on PA promotion. A meta-analysis conducted by Howlett et al. [15] showed small-to-moderate effects of PA intervention in healthy adults. Participants of the included studies increased their weekly activity by 31 to 247 min in the short-term and by 5 to 95 min in the long-term. However, effects on objectively assessed PA were small and, therefore, declared as non-significant in the post and follow-up assessments. In terms of the intervention content, the findings also correspond to earlier studies. As a recent review confirmed, especially those interventions applying the BCTs self-monitoring, goal setting, feedback on outcome of behavior, setting graded tasks and add objects to environment [13] as well as action planning, instruction on how to perform the behavior, prompts/cues and behavior practice/rehearsal [15] have been shown to be effective. Hence, a client-centered coaching in which autonomy is strengthened, as has been the case in the present intervention, seems to be particularly important for long-term effects [13]. Thus, presented effects of telephone coaching are consistent with the expected effects of applied BCTs.

The decrease in objectively assessed MVPA of the control group might possibly be explained by an unconscious change in PA behavior of all groups during baseline measures. Previous studies have shown higher activities of participants newly wearing a PA tracker [49]. The device applied in the present study (ActiGraph) should have had minimal influence on the behavior, as it did not allow for self-monitoring (no display). Additionally, participants were explicitly asked not to let the device influence their regular behavior. However, the mere fact of wearing a device as well as the motivation to participate in a study on PA promotion [50] might have resulted in subconscious PA level increases above usual ones.

The SMS prompting did not lead to further increases in PA compared to telephone coaching alone. Both intervention groups showed very similar PA levels in both assessment methods in the post and follow-up test. On the contrary, existing reviews show that the majority of text messaging interventions resulted in positive effects on health-related behaviors, especially when messages were individually tailored [21,51,52]. Patrick et al. [53] demonstrated that two to five text messages per day with additional monthly phone calls had a positive effect on weight loss when compared to monthly printed information. However, to our knowledge, there is no study that compared a telephone coaching intervention with or without prompts. In the present study, participants appreciated receiving SMS prompts and considered them as supportive. According to personal feedback given to coaches, participants repeatedly wished to be able to respond to the messages. Thus, the effectiveness of SMS might hypothetically have been increased by providing the option to respond. A more likely explanation for the similar results in the coaching and SMS group and the coaching group might be that the coaching alone was sufficient and that smaller beneficial effects of additional prompts were ineffective due to the ceiling effects.

The control group showed a relevant increase in self-reported PA (86 min in the short-term and 99 min in the long-term). Participants in the control group received a minimal credible intervention which

was considered comparable to tailored online information or recommendations given by a general practitioner. Participants reported to have read their recommendation one to three times and median use of the activity profile was 2.6/month. This leads to the conclusion that a minimal intervention as well as participating in a study on PA promotion [50] affected self-reported PA levels positively. Previous studies have shown bigger effects when interventions were compared to a traditional control group or a waiting list [54]. This holds true especially for long-term effects, as those are generally smaller [15]. Observed group differences in the present study, therefore, underline the positive effects of the coaching intervention.

4.2. Adherence and Acceptance

The dropout rate was higher in the control group compared to the coaching groups. Each participant was asked to attend the assessments independently of whether they actually interacted with the program. However, 20% of the control group did not answer the request for the post-test and reasons remain mainly unknown. Six percent of the coaching group and 13% of the coaching and SMS group were lost to follow-up. In these groups, an additional 8% (coaching) and 2% (coaching and SMS), respectively, stopped the coaching, but completed the assessments. One-third of the reasons for dropouts and non-usage attrition of the intervention groups were unrelated to the intervention (pregnancy, illness, personal issues). However, eleven participants reported lack of time and lack of motivation to continue. Observed dropout and non-usage attrition rates were low compared to other remote PA promotion interventions [10,15,17]. This allows the conclusion that the intervention was suitable for participants with limited time availability. The extent of acceptance of the program was also confirmed by the fact that 95% of participants reported being satisfied with the telephone coaching. Additional open-ended questions indicate that the personal relationship with a coach as well as the lack of any on-site presence were particularly appreciated. The duration and frequency of the calls were mainly rated as fitting. According to the feedback of coaches, it is still suggested to individualize the frequency and number of coaching sessions in a practical implementation.

The use of the online platform to plan, self-monitor, and interact with the coach was appreciated by participants. The platform was mainly used to facilitate interaction and to enrich the coaching sessions through self-monitored PA. During the follow-up period, all participants stopped using the platform. Participants were asked to keep self-monitoring and planning; however, the method used to do so was clearly communicated to be the participants' choice. The platform remained unchanged for the entire study period. According to previous studies, it would not be surprising that usage declined if there was no new content added or updates [22].

4.3. Strengths and Limitations

The target group of the current study were insufficiently active adults. However, 27% of participants already fulfilled PA guidelines at baseline. These participants reported less than 150 min in a preceding screening questionnaire but were more active during the week of the first assessment. The present results are, therefore, not generalizable for a completely inactive target group. Additionally, the sample consisted of rather well-educated, employed participants with little child-caring responsibilities, who voluntarily joined the study. This self-selection recruitment further reduces the generalizability of the results.

Absolute MVPA minutes/week largely differed between objective and subjective measures: objective measures showed higher baseline activity and smaller changes from baseline to post-test compared to self-reported measures. A discrepancy between objective and subjective measures has been observed repeatedly [55] and might partially be explained by methodological limitations of both assessment methods. On the one hand, wrist acceleration does not record all forms of PA (e.g., cycling) and the amount of minutes declared as MVPA depends strongly on selected cut off values [38]. To date, there are no established cut off points for wrist-worn ActiGraph data but other devices have shown to accurately classify PA [56]. The present study applied cut off values that were

considered most appropriate according to an explorative study with free-living elderly women [37]. This lack of validated cut off values for wrist-worn ActiGraph data leads to two limitations. First, the absolute minutes of MVPA need to be interpreted cautiously, as they might be inaccurate. Second, the comparability to previous studies is limited. The two limitations were accepted in order to achieve a higher wear compliance within the remote study setting [57]. Previous studies have shown high correlations of wrist- and hip-worn accelerometer data with comparable classifications of PA intensities [37,56,58]. Wrist-worn ActiGraph counts were, therefore, considered reasonable to assess between-group differences and changes over time. On the other hand, self-reported PA might be subject to recall bias and social desirability [59,60]. Increases in self-reported PA might be biased since participants focused on PA behavior during the intervention. In contrast to a study design with a traditional control group, the difference in bias between the three intervention arms might have been reduced, as the control group received a minimal credible intervention with the opportunity to use the online platform and access to a training plan example. Participants were unaware that their group served as a control group and they were likewise asked to plan, self-monitor, and increase their PA behavior. Consequently, absolute values of subjective and objective minutes of MVPA need to be interpreted cautiously. The combination of both measurement methods is still considered a strength of the study. Even though minutes of MVPA differ between the two methods, both measures clearly show benefits of remote PA counselling in the post and follow-up-test.

5. Conclusions

The presented three-armed study compared the efficacy of different intervention delivery modes to promote PA. The study's no-contact follow-up enabled conclusions on the maintenance of PA behavioral changes. The combination of self-reported and objectively assessed PA tackled the limitations of both methods. In conclusion, the study shows that telephone coaching based on established BCTs leads to higher PA levels compared to a minimal intervention. Additional SMS prompts do not help to further increase PA levels. Increases in self-reported PA were maintained over time. Objectively assessed PA decreased after the end of the intervention. Nevertheless, group differences in favor of the intervention groups persisted. The coaching was highly accepted and associated with low dropout rates. Overall telephone coaching can be considered an efficacious and well-accepted tool for the promotion of a physically active lifestyle in adults of working age.

Supplementary Materials: The following are available online at http://www.mdpi.com/1660-4601/16/14/2626/s1: S1: Supplementary file on perceived fitness: Figure S1: Summary statistics. Table S1: Baseline adjusted change scores and between group differences. S2: Supplementary file on acceptance and perception related questions: Table: Mean and standard deviation per study arm.

Author Contributions: X.F. led the coordination of the study, developed the study procedure, collected the data for the present report, and drafted the manuscript with input and advice from all authors. L.D. and L.Z. generated the idea for the project and secured the funding for the study. O.F. and M.G. participated in the design. J.-N.K. contributed to the analyses of the accelerometer data and to the data collection. L.D. and O.F. contributed to the statistical analysis for this report. L.D., L.Z., O.F., M.G. and J.-N.K. critically commented on the drafted manuscript. All authors read and approved the final manuscript.

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Supplementary Material

Telephone-Based Coaching and Prompting for Physical Activity: Short- and Long-Term Findings of a Randomized Controlled Trial (Movingcall)

Xenia Fischer, Jan-Niklas Kreppke, Lukas Zahner, Markus Gerber, Oliver Faude and Lars Donath

S1: Supplementary File on Perceived Fitness

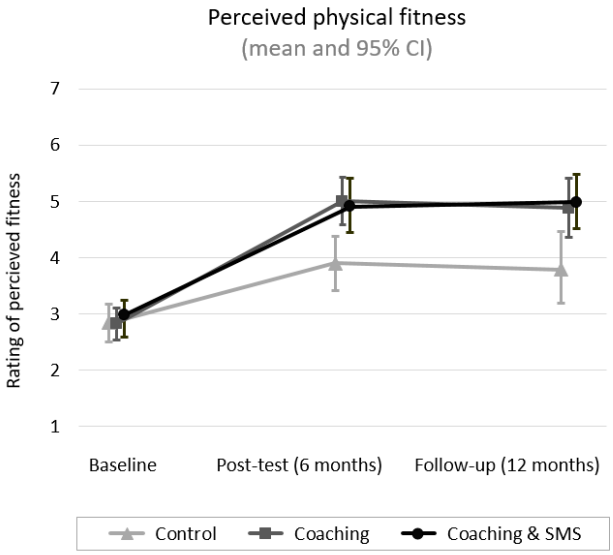

Figure 1. Unadjusted means and boot-strapped bias-corrected and accelerated confidence intervals of self-rated physical fitness. *N* = 285 at baseline, *n* = 205 at 6 months and *n* = 177 at 12 months.

Table 1. Adjusted changes in perceived physical fitness within groups and differences between groups at each time point

	Adjusted Mean Change from Baseline (95% CI)			Pairwise Comparison: Differences among Groups in Change from Baseline (95% CI)		
M	**Control**	**Coaching**	**Coaching and SMS**	**Coaching vs. Control**	**Coaching and SMS vs. Control**	**Coaching and SMS vs. Coaching**
6	1.1 (0.7 to 1.5)	2.1 (1.7 to 2.5)	2.0 (1.5 to 2.4)	1.0 (0.4 to 1.6)	0.9 (0.3 to 1.5)	-.1 (-0.7 to 0.4)
12	0.9 (0.4 to 1.4)	2.1 (1.7 to 2.5)	2.1 (1.7 to 2.5)	1.2 (0.5 to 1.8)	1.2 (.6 to 1.8)	0.04 (-.5 to 0.6)

M = Months.

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S2: Supplementary File on Acceptance and Perception Related Questions

Table1. Acceptance and perception related questions: Mean and standard deviation per study arm.

	Time of Assessment	Translated Question	Translated Answer on Likert Scale	Control Mean (SD)	Coaching Mean (SD)	Coaching and SMS Mean (SD)	p-value ANOVA	η2
General acceptance and perception of intervention	6 months	In general, I am satisfied with this intervention.	1 = not true 2 = rather not true 3 = rather true 4 = true	**2.0 (0.8)**	**3.5 (0.6)**	**3.7 (0.6)**	< 0.001	0.481
	6 months	The program helps me to achieve my physical activity and exercise goals.	1 = not true 2 = rather not true 3 = rather true 4 = true	**1.7 (0.8)**	**3.4 (0.7)**	**3.4 (0.6)**	< 0.001	0.463
	6 months	This program helps me to be more physical active in my everyday life in the long-term (>1 year).	1 = not true 2 = rather not true 3 = rather true 4 = true	**2.2 (1.1)**	**3.5 (0.8)**	**3.6 (0.6)**	< 0.001	0.284

	6 months	This program will help me in the future to motivate myself to be regularly physically active.	1 = not true 2 = rather not true 3 = rather true 4 = true	**2.1 (1.1)**	**3.4 (0.7)**	**3.4 (0.7)**	< 0.001	0.286
Activity profile	3 months	In general, the profile on www.movingcall.com is understandable and easy to use.	1 = not true 2 = rather not true 3 = rather true 4 = true	**2.8 (1.0)**	**3.3 (0.7)**	**3.3 (0.7)**	< 0.001	0.074
	3 months	Did you use "my plan"? (e.g. to adapt the plan, to look up exercises in the catalogue or to write a note)	1 = No, never 2 = Rarely 3 = Yes, but irregularly 4 = Yes, regularly	**2.6 (0.9)**	**3.3 (0.8)**	**3.3 (0.8)**	< 0.001	0.090
Perception and participation of the control group	3 months	How often did you read the entire recommendation on physical activity?	Number	**2.4 (3.0)**				
	3 months	Is the recommendation formulated in an understandable way?	1 = no 2 = rather no 3 = rather yes 4 = yes	**3.6 (0.8)**				
	3 months	Is the advice in your recommendation tailored to your personal situation in life?	1 = no 2 = rather no 3 = rather yes 4 = yes	**2.6 (0.9)**				

Perception and participation of the coaching and the coaching & SMS group	6 months	Did the phone calls take place regularly?	1 = no 2 = mostly 3 = yes	**2.9 (0.3)**	**2.9 (0.3)**	0.520	0.009
	6 months	The duration of the phone calls was …	1 = too short 2 = appropriate 3 = too long	**2.0 (0.2)**	**2.0 (0.1)**	0.368	0.005
	6 months	The intervals of the phone calls were …	1 = too short 2 = appropriate 3 = too long	**2.0 (0.3)**	**2.0 (0.2)**	0.749	0.004
	6 months	My coach and I had a trusting relationship.	1 = not true 2 = rather not true 3 = rather true 4 = true	**3.8 (0.5)**	**3.9 (0.3)**	0.524	0.015
	6 months	Our relationship was characterized by mutual respect.	1 = not true 2 = rather not true 3 = rather true 4 = true	**3.9 (0.2)**	**4.0 (0.2)**	0.311	0.006
	6 months	I was coached according to my current state of my physical activity (e.g. appropriate goals were set).	1 = not true 2 = rather not true 3 = rather true 4 = true	**3.9 (0.4)**	**3.9 (0.4)**	0.498	0.009
	6 months	I do collaborate with my coach during the coaching process.	1 = not true 2 = rather not true 3 = rather true 4 = true	**3.7 (0.5)**	**3.8 (0.5)**	0.649	0.006

Perception and participation of the coaching & SMS group	6 months	Did you always receive 4 SMS between the calls?	1 = I have not received any SMS 2 = No, not always 3 = Yes, always	**2.9 (0.3)**
	6 months	Do you perceive the SMS overall as supporting?	1 = No, they are not supportive 2 = No, they are rather not supportive 3 = Yes, they are more supportive 4 = Yes, they are supportive	**3.4 (0.8)**
	6 months	How do you rate the frequency of the SMS?	1 = Too rare 2 = Appropriate 3 = Too often	**2.1 (0.4)**

Chapter 5
Publication 3

Exploring psychosocial mediators of remote physical activity counselling: A secondary analysis of data from a 1-year randomized control trial (Movingcall)

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Chapter 6
Synthesis, discussion and perspectives

Chapter 6 Synthesis, discussion and perspectives

This PhD project comprises the preparation, implementation and analysis of a one-year randomized control trial called “Movingcall”. We examined the efficacy of telephone coaching and SMS prompting for physical activity promotion in adults. Short-term changes in physical activity level, maintenance of achieved physical activity level as well as working mechanisms by which the intervention influenced physical activity levels were analyzed. This chapter summarizes and discusses the main results of the study.

6.1 Synthesis

The analyzed physical activity promotion program was developed based on existing evidence, theories and practical considerations on how to reach a working-aged, physically inactive target group. The program consists of evidence-based BCTs and is individually tailored. Three versions to communicate the program were compared in the three-armed randomized control trial with a six-month intervention and a six-month no-contact follow-up period [1]. Two hundred and eighty-eight men and women were randomly assigned to one of the study arms [2]. The two intervention groups received 12 biweekly telephone coaching sessions (coaching group, coaching and SMS group). In collaboration with their coach, participants elaborated on BCTs to overcome barriers to reach personal physical activity goals. Participants of the coaching and SMS group additionally received four text messages between each coaching session (48 SMS in total). These two coaching interventions were compared to a minimal credible intervention consisting of a single written recommendation (control group). Participants of all study arms had access to a personal activity profile for planning and self-monitoring of physical activity. In the coaching groups, these profiles additionally served to facilitate the coach-coachee interaction. Outcome measures were assessed at baseline, after the intervention (6 months) and after the follow-up period (12 months). Self-reported and objective MVPA during one week was assessed by a structural interview and by accelerometer. Additionally, psychosocial determinants of physical activity as well as information on acceptance of the intervention were assessed by online-questionnaires [1].

6.1.1 Aim 1: Short-term effects

After the six-month intervention, 239 participants completed the interview to assess self-reported physical activity. Valid accelerometer measurements were achieved in slightly fewer subjects (n = 213). Seventy-seven per cent of all randomized participants completed the intervention according to the study protocol [2]. Dropout after six months differed between the control group (20%), the coaching group (6%) and coaching and SMS group (13%).

Compared to baseline, self-reported MVPA had increased in all three groups. However, increases in MVPA were 173 minutes/week (95% CI 95 to 252) higher in the coaching group and 165 minutes/week (95% CI 84 to 246) higher in the coaching and SMS group compared to the control group. The control group increased its self-reported MVPA by 87 minutes/week (95% CI 28 to 145).

Objectively assessed MVPA only increased in the two intervention groups and remained similar to baseline values in the control group. Wrist acceleration declared as MVPA was 32 minutes/week (95% CI 0 to 63) higher in the coaching group and 34 minutes/week (95% CI 2 to 66) higher in the coaching and SMS group compared to the control group. The two intervention groups showed similar levels of MVPA in self-reported and objectively assessed physical activity [2].

6.1.2 Aim 2: Long-term effects

After six months of follow-up, during which participants were not contacted, interview data on self-reported physical activity was obtained in 217 participants and valid accelerometer measurements in 191 participants. Dropout-levels remained higher in the control group (32%) compared to the coaching (13%) and the coaching and SMS group (14%) during this measurement period [2].
Observed group differences between the two coaching interventions and the control group persisted in the follow-up. Increases in self-reported MVPA were 112 minutes/week (95% CI 30 to 195) higher in the coaching group and 113 minutes/week (95% CI 29 to 198) higher in the coaching and SMS group compared to the control group. These changes in self-reported MVPA were similar to the ones achieved directly after the end of the intervention in all three groups. In contrast, objectively assessed MVPA levels of the two intervention groups decreased and were similar to baseline values after the follow-up. Group differences persisted however, as the level of MVPA in the control group decreased bellow baseline by 26 minutes/week (95% CI -50 to -2). Changes in objectively assessed MVPA levels were 33 minutes/week (95% CI 1 to 65) higher in the coaching group and 42 minutes/week (95% CI 9 to 75) higher in the coaching and SMS group compared to the control group. As directly after the intervention, SMS prompts did not contribute to an extended increase of MVPA levels. The two intervention groups showed similar values for self-reported and for objectively assessed MVPA [2].

6.1.3 Aim 3: Working mechanisms

The impact of the intervention on seven psychosocial determinants of physical activity as well as the mediating influence of these determinants on changes in self-reported and objectively assessed MVPA were analyzed in a secondary analysis. For this purpose, the two intervention groups were jointly compared to the control group. Questionnaire data on psychosocial determinates were obtained from 239 participants after the intervention (six months) and from 219 after the follow-up (12 months) [2].
The analysis revealed a positive effect of the coaching intervention on action planning, barrier management, self-efficacy, outcome expectations and intention strength after six months. Effects of the intervention on action planning and barrier management persisted after the no-contact-follow-up. Against our theoretical assumptions, changes in these determinants were very weakly associated with increases in self-reported and objectively assessed MVPA. Increases in objectively assessed MVPA levels after six months were mediated through increased barrier management. However, none of the other investigated determinants functioned as mediating factors for increases in self-reported or objectively assessed MVPA [3].

6.2 General discussion

6.2.1 Telephone coaching

The Movingcall study demonstrated the potential of telephone coaching to promote physical activity among a working-aged population in Switzerland. Our results on short and long-term changes in MVPA confirm and extend previous findings on telephone delivered and health coaching based physical activity promotion [37,60,80]. They are also in accordance with findings from studies and reviews that were published during the course of this study [36,71].

Concerning self-reported physical activity level, effects of the present intervention were larger compared to earlier studies. Existing studies on telephone-based physical activity promotion usually reported moderate effects on short-term changes in MVPA [77,80]. Thereby, achieved increases in minutes of MVPA strongly depended on the applied assessment tool and on baseline physical activity levels of the participants [133]. Reviews on physical activity promotion programs, which conveyed effect sizes in minutes/week suggested that a moderate effect corresponds to an increase of MVPA from 15 minutes [134] up to 73 minutes [135] per week. In the present study, the coaching groups increased their MVPA by about 150 minutes/week compared to the control group. Maintenance effects on self-reported physical activity levels were less evident according to earlier literature. Fjeldsoe et al. [136] for example concluded that maintenance of self-reported physical activity can be achieved, but that only very few studies report outcomes after a follow-up period during which participants were not contacted. Concerning health coaching interventions, Dejonghe et al. [71] reported in a recent review that six of 14 included studies showed long-term efficacy. In this regard, the present study met the demand for a follow-up and confirmed the results of previous studies, which observed sustainable increases in physical activity level through telephone coaching. Once achieved increases in self-reported physical activity were maintained in all three study arms [2].

Objectively assessed MVPA levels were also higher in the coaching groups compared to the control group. The difference was about 30 minutes/week directly after the intervention as well as after the six-month follow-up [2]. However, group differences in the follow-up only persisted as the control group declined below baseline. Once achieved increased physical activity levels of the two intervention groups were not maintained in the follow-up. So far, there are only few studies on telephone-based physical activity promotion, which applied objective measures of physical activity [37,103]. Compared to self-reports, documented short-term increases in objectively assessed physical activity levels were usually smaller [36,137,138]. Previous studies assessing objectively measured physical activity levels after a no-contact-follow-up showed even smaller or no effects [137,138]. This conclusion was also reached by a recent meta-analysis on physical activity behavior change interventions in healthy adults, including studies with variable settings and delivery modes [36]. Studies applying a self-report measure showed a post intervention effect size of d = 0.39 and a follow-up effect size of d = 0.23. On the other hand, studies using objective measures presented small and non-significant effect sizes post intervention (d = 0.14) and at follow-up (d = 0.16). Thus, in line with previous findings, long-term effects on objectively assessed outcomes are considered least conclusive. Concerning group differences, objectively assessed measures confirm the findings on self-

reported physical activity levels. With regard to possible bias of self-reported data [105-107], maintenance effects should however be interpreted carefully.

Increases in physical activity levels that were achieved in the present trial are considered highly relevant for the prevention of non-communicable diseases. This conclusion is based on large studies that demonstrate a dose response relationship between self-reported physical activity and the risk for all-cause mortality [12,139]. Usually the greatest relative risk reduction is observed when comparing completely inactive individuals to those that participated in low volumes of physical activity [140,141]. Wen et al. [142] revealed that already 15 minutes of moderate-intensity exercise per day resulted in a 14% reduction in all-cause mortality. However, every additional 15 minutes/day further reduced all-cause mortality by 4%. Thus, even if participants in the present study were not completely inactive at baseline, their average increase in self-reported physical activity (about 15 minutes/day in the control group and about 35 minutes/day in the intervention groups) is associated with relevant health benefits. With this in mind, the observed group differences of about 20 minutes/day need to be considered as relevant too.

Participants' feedback as well as their adherence to the program indicate that the telephone coaching was well accepted. Ninety five per cent of the coaching groups reported being satisfied with the telephone coaching. Over 90% of the coaching groups and 33% of the control group rated the program as "supportive" in order to reach personal physical activity goals. The duration and frequency of the coaching calls were also predominantly rated as fitting [2]. However, responses to open-end questions indicate that participants and coaches would appreciate the possibility to individually adapt the frequency of calls. At the end of the intervention individuals were asked, if they would additionally wish a face-to-face meeting. The fact that only 30% of the intervention groups wished to meet their coach in person underlines the acceptance of the remote setting.
The dropout rate was lower in the coaching group and the coaching and SMS group compared to the control group. Considering the difference in dropout rates between the two intervention groups one should take non-usage attrition into account. Eight per cent of the coaching group and 2% of the coaching and SMS group withdrew from the intervention but participated in the assessments. Accordingly, about 14% of both coaching groups withdrew from the intervention. Thereby, two third of the reasons for dropout and non-usage attrition were related to the intervention as participants reported lack of time or motivation to continue. One third withdrew from the study due to other reasons like pregnancy or private issues. Compared to other remote delivery modes and especially compared to web-based interventions these dropout rates were notably low [94,95]. We therefore conclude that telephone coaching is particularly beneficial to achieve adherence to a physical activity promotion program.

The personal coach-coachee-relationship was highly appreciated according to the feedback of participants. Statements like "it was very valuable to have someone who responded to your personal needs, who encouraged you to think about yourself, and to whom you had to be accountable after two weeks" were frequently mentioned in open-end questions. These responses are in line with the autonomy supportive and client-centered partnership that characterized the telephone coaching [1]. A consistent relationship between coach and coachee is considered the basis of a successful health coaching process [60,62]. Interestingly, a recent meta-analysis has shown that such an autonomy

supportive, person-centered communication style is associated with long-term behavioral changes [41]. In the field of psychotherapy, there is a great deal of research on the influence of a personal relationship (so called therapeutic or working alliance) [143-145]. A good therapeutic alliance has been shown to account for seven to 15% of the gains made in psychotherapy [146] and was associated with positive outcomes in the treatment of chronic diseases [147]. Existing studies indicate that a good therapeutic alliance can also be achieved via telephone [148]. This finding was confirmed in the present study, as the quality of the relationship (assessed by rating the trust within the relationship) was rated very highly. However, it remains unknown to what extent the personal relationship actually contributed to increases in physical activity level or if automated communication might result in similar results [149].

6.2.2 SMS prompting

SMS prompting did not lead to additional increases in physical activity compared to telephone coaching alone [2]. This would have been expected based on existing research, in particular because messages were individually tailored [85,88,150]. Fjeldsoe et al. [151] for example showed increased self-reported frequency of physical activity participation as a result of five tailored SMS prompts per week over a period of 12 weeks.

Even if the SMS were not associated with increased efficacy, they were perceived as supportive or rather supportive by 86% of participants. We therefore hypothesized that the coaching itself was already sufficient to achieve increases in physical activity level and that additional benefits of SMS prompting were not apparent due to a ceiling effect. This additional benefit of SMS prompts has, to our knowledge, not been analyzed to date. Thus, it would be interesting to investigate whether SMS prompts result in an additional benefit, if fewer and less frequent coaching calls were provided in a future study. Thereby, an individual adaption of the message frequency should be considered. In the present study, the timing of the messages varied within self-selected time slots but the frequency was the same for all participants (four messages between each coaching session). According to a review by Head et al. [150], an individual adaption of the message frequency might have increased the efficacy of the intervention. SMS prompts were also discussed as a possibility to extend an intervention, e.g. after telephone coaching [136]. From this perspective, it would also be interesting to investigate whether self-reported and objectively assessed physical activity levels might be better maintained or further increased if SMS prompts were sent during the follow-up period.

6.2.3 Minimal intervention and activity profiles

Participants who received a single written recommendation and had access to an activity profile (minimal intervention = control group) showed a relevant increase in self-reported physical activity level after six and after 12 months [2]. This was expected due to existing literature. Previous findings indicate that written interventions [152,153] as well as the sole participation in a study on physical activity promotion [154] affect self-reported physical activity levels positively. For this very reason, the two intervention groups were compared to a minimal credible intervention instead of a waiting list or a traditional control group [155]. We intended to assess the additional benefit of coaching and prompting beyond a treatment that could be considered as “treatment as usual”. In order to overcome the bias of a control group [108], the participants receiving this minimal intervention were

never told they were in the "control group". Still, the minimal intervention group was least preferred by the participants. As described above, only 33% of the control group considered the intervention to be supportive. The dropout rate in this group was the highest (20% after six months and 32% after 12 months) and similar to web-based interventions with little personal support [94,95]. Unfortunately, dropout reasons remained largely unknown in this group.
In contrast to self-reported physical activity, objectively assessed physical activity in the control group remained unchanged after six months and decreased below baseline level after 12 months. An unconscious increase in baseline physical activity beyond the usual physical activity behavior has been discussed as a possible reason for this observation [2]. However, the actual reason remains unknown.

The activity profiles were designed to simplify action planning and self-monitoring. The profile could have been used as a stand-alone tool or to simplify interaction between participant and coach. The number of active edits per months within the profile indicate however that the activity profiles were mainly used during the coaching process. Participants of the minimal intervention groups as well as all participants during the follow-up period rarely engaged with their activity profiles [2]. One reason for the decreased use in the follow-up period might be that coaches encouraged their participants to find an individually fitting method to continue planning and self-monitoring. This might have been the activity profile but could just as well have been paper and pencil or an office calendar for example. However, the low engagement with the activity profile is not surprising when taking experiences of current research into account. Regular updates and changes in content as well as excellent user-friendliness are key to regular engagement [95]. In the present study, the activity profiles were kept unchanged in order to standardize the information provided to all participants. This does not correspond with a procedure in a real world setting and highlights the difficulty of carrying out RTCs with constantly evolving online-communication-tools [156]. Besides, the ratings on user-friendliness showed clear potential for improvement. In particular, participants would have preferred an app instead of a web-based application. Nevertheless, the availability of the profiles was overall largely appreciated.

6.2.4 Theoretical foundation and analysis of proposed working mechanisms

The present intervention applied an a priori defined logic model. The effect of applied BCTs on psychosocial determinants and subsequently the physical activity behavior were predicted according to the MoVo Process Model [121] and the Behaviour Change Wheel framework [118]. The relationship between the two theories was carefully analyzed in preparation of the study. Taking the Theoretical Domains Framework [119,120] into account, a link between the two theories was established. These theoretical assumptions then informed the development of the physical activity promotion program. However, they also allow the verification of made assumptions and thus the analysis of why the intervention was efficacious. The latter was examined in a secondary analysis. As expected according to previous literature [115,116] and theories [118,121], the promotion of evidence-based BCTs in a personal telephone coaching resulted in beneficial changes in psychosocial determinates of physical activity (self-efficacy, outcome expectations, intention strength, self-concordance, action planning, barrier management, social support). Thereby, the strongest and most sustainable effects of the coaching interventions were observed on action planning and barrier

management [3]. The latter is not surprising considering that action planning and problem solving were among the most frequently applied BCTs (see 6.2.5). Contrary to our expectations, observed changes in the assessed determinants were only weakly associated with changes in self-reported or objectively assessed physical activity. The working mechanisms of telephone coaching for physical activity promotion remain therefore largely unknown. This result complements the controversial findings from previous mediation analyses of physical activity promotion [117]. Several studies on telephone-based physical activity promotion observed a mediation of self-reported physical activity through self-regulatory constructs [157-159]. However, there are also studies that found no mediation of either self-reported or objectively assessed physical activity through psychosocial determinants [160,161]. Considering these results, we suggest that additional determinants, such as perceived stress or skills [31], might be considered in future mediation analysis.

6.2.5 Intervention content

The present study combined intervention components that have proven efficacious in previous interventions. Ten evidence-based BCTs constituted the core of the present intervention [1]. Interestingly, the evidence that these BCTs positively effect physical activity levels was largely confirmed by recent reviews and meta-analyses. Samdal et al. [41] for example, concluded that "goal setting" and "self-monitoring" were important for short and long-term behavior changes concerning physical activity or healthy eating in overweight adults. A review by Howlett et al. [36] on physical activity interventions for healthy inactive adults concluded that the BCTs "biofeedback", "demonstration of the behavior", "behavior practice/rehearsal," and "graded tasks" were associated with increased physical activity in the short-term. Maintenance of behavior change was achieved in interventions applying "action planning", "instruction on how to perform the behavior", "prompts/cues", "behavior practice/rehearsal", "graded tasks", and "self-reward" [36]. Besides the ten core BCTs, further intervention characteristics were determined based on existing literature. This included 25 additional BCTs, the duration of the intervention, the frequency of coaching calls and the communication style according to the health coaching principle [1]. In order to standardize the intervention delivery, these contents and procedures were documented precisely in written guidelines which were taught to the 28 coaches.

Applied BCTs of each coaching session were documented by the coaches. In doing so, we met the demand for a precise process evaluation in tailored interventions [125,127]. To our knowledge, we thereby proceeded more precisely than previous studies. A documentation at the level of individual BCTs for each session has not been described in earlier interventions [162]. In the present intervention, most frequently applied BCTs turned out to be "action planning", "feedback on behavior", "self-monitoring of behavior", "problem solving" and "goal setting" [2]. At the beginning of the intervention coaches applied "goal setting", "information about health consequences", self-monitoring" and "set graded tasks" more frequently. Towards the end of the six months coaches focused on "information about individual health consequences", "habit formation" and "feedback". This varying use of BCTs reflects that coaches supported the individuals in forming a habit of once achieved physical activity levels.

At the end of the intervention, participants were asked which BCTs they perceived as most useful to adopt and maintain regular physical activity. Their responses are in agreement with current meta-

analysis on effective BCTs for physical activity promotion [36,41] and allow the conclusion that especially “action planning” and “problem solving” should be included in remote physical activity promotion programs.

6.2.6 Discrepancy between self-reported and objectively assessed physical activity

Self-reported (via interview) and objectively assessed (via accelerometer of the brand ActiGraph) absolute values in minutes of MVPA per week strongly differed in the present study. Baseline levels of MVPA assessed by accelerometer were higher and changes in minutes of MVPA over time were nearly ten times smaller compared to self-reported MVPA. If changes were expressed in a multiple of their baseline standard deviation (effect size) the difference between the two assessment methods would be smaller. Accordingly, the difference in the direct intervention effect in the secondary analysis was smaller too. Previous studies on remote physical activity promotion, which applied both assessment methods usually reported an objectively assessed number of steps per week and compared these to self-reported minutes of MVPA [103,137]. Doing so, the studies avoided a direct comparison of two intensity-specific physical activity levels, which are obtained differently. In this study, it was decided that the most meaningful use of accelerometer data would be to convert it into minutes of MVPA per week. Thus, when comparing these minutes per week, their different origin as well as limitations of both assessment methods need to be considered.

A discrepancy between self-reported and objectively assessed physical activity has been observed repeatedly [163-165]. As Prince et al. [164] demonstrated correlations of self-reported and objectively assessed physical activity range from minus 0.71 to plus 0.96. These statistics highlight the fact that, although both assessment methods provide an estimate of energy expenditure, they do not capture the same phenomenon [166]. Self-reported assessment methods allow the specification of the type and duration of structured physical activities [104]. Accelerometers on the other hand measure the acceleration of an individual’s wrist or hip [109]. Some limitations, such as the fact that an accelerometer does not detect cycling or that self-reported activities depend on recall capacity, seem obvious [109]. However, the two measurement methods can differ considerably even if an activity is well remembered and involves whole-body movements that are well recorded by accelerometers. If an individual for example plays basketball for 60 minutes that person might remember one hour of MVPA. The accelerometer by contrast would record light intensity activity and sedentary behaviors during pauses in play or while the player is sitting on the bench. Accelerometers on the other hand would record the walk from the parking lot to the play court and back as moderate activity whereas this short path might not be reported in an interview [133].

The accelerometer data of this study were categorized by intensity levels. This common procedure allows to quantify whether a person has, for example, achieved the minimum recommended amount of 150 minutes MVPA per week [17]. However, the intensity-specific physical activity levels strongly depend on the cut-off values that are applied to classify the intensities [111]. These cut-off values were developed by analyzing the relationship between accelerometer counts and objectively measured energy expenditure of certain activities under laboratory conditions [167]. However, the sample as well as the set of applied activities in these calibration studies are frequently not representative for a real world setting [111]. As a consequence, depending on selected cut-off values,

the prevalence of individuals declared as insufficiently active strongly differed between self-reported and objectively assessed measures [168].
One should also consider that physical activity recommendations (150 minutes per week) are based on epidemiologic studies, which associate health outcomes with self-reported physical activity [17]. It is unknown how many accelerometer counts or just how much acceleration is needed to achieve a relevant reduction in the relative risk of non-communicable diseases.

The present study applied wrist-worn accelerometer assessment. Generally, hip-worn accelerometers are superior to predict energy expenditure as wrist-worn acceleration overestimates movements of the body [169]. However, wrist-worn accelerometers have shown much higher wear time compliance compared to the assessment on the hip [166] and the correlation of measures assessed at the wrist and at the hip is high [170-172]. This is also the reason why wrist-worn accelerometers are increasingly applied in cohort studies [166,173,174]. Currently, there is a number of large studies underway. There is hope that these studies will allow conclusions to be made on how much acceleration of the wrist needs to be achieved for relevant health benefits [174]. Thus, it is possible that in future the above mentioned limitations of cut-off values to quantify health relevant physical activity can be circumvented [166].
In the present study, the decision to use a wrist-worn assessment did however lead to the limitation that there are no established cut-off values for wrist-worn accelerometer counts of the brand ActiGraph. Applied cut off-values have proven to correctly categorize the intensity in an exploratory study with elderly woman [175]. This complements the general limitations of cut-off values and implies that objectively assessed minutes of MVPA should be interpreted very carefully. The observed high baseline values of objectively assessed physical activity leads to the assumption that minutes of MVPA might be overestimated. Further, the sensitivity to change of wrist-worn acceleration, applying laboratory cut off values is not known. Against this background, also absolute values of the changes over time must also be considered carefully.
The main objective of the present study was, however, to analyze between group differences in changes over time. This hypothesis can also be examined if the absolute values in minutes are not entirely conclusive. With regard to group differences, the objective values confirmed the subjective ones. Due to the described limitations and in order to enhance comparability with existing studies, self-reported activity served as the main outcome of this study.

6.2.7 Summary of strengths and limitations

The study design, the applied assessment methods and the precise process evaluation enabled the PhD project to overcome some shortcomings of earlier research [72,80,89,95,125]. The three-armed study design enabled the comparison of different combinations of delivery modes and the follow-up assessment allowed conclusions on the sustainability of observed changes in physical activity level. Even if the comparison of objective and self-reported activity is challenging (see 6.2.6.), its combined application is considered the strength of the study. The results of the two assessment methods are interpreted with regard to their limitations and complement each other. The exact documentation of the coaching is considered a further strength as it allowed a precise description of the intervention fidelity. Furthermore, we met the demand for an exact description of the intervention by publishing the study protocol. Finally, it is considered as a strength of the study that the remote setting was preserved. According to open-end questions on barriers, we thereby managed to reach a target group with typical barriers for physical activity [28] (most frequently named barriers were motivation, time and stress).

The study nevertheless has some limitations that should be considered. First, the intervention was aimed at insufficiently active adults. However, 27% of participants fulfilled physical activity guidelines at baseline [2]. This is due to the fact that the physical activity level of one week served as an inclusion criterion and the physical activity level of another week was assessed at baseline. In order to quantify this limitation, we conducted an exploratory analysis on the data without individuals who reached physical activity guidelines at baseline. This analysis resulted in a slightly higher increase of physical activity but similar group differences in self-reported and objectively assessed physical activity. Nevertheless, the results are strictly speaking only generalizable for employed adults, who have not been completely inactive and who were motivated to increase their physical activity level.
Second, as with all behavioral interventions, the group allocation could not be blinded towards participants [108]. Self-reported outcomes are therefore prone to social desirability as well as the influence of optimistic expectations [105,176]. As mentioned before, the minimal intervention (placebo group) was chosen to reduce the bias induced by the knowledge of the group allocation [108]. All three groups received the same intervention content but the density of delivered information as well as the delivery mode varied. To reduce biased dropouts, participants were asked to complete the assessment period regardless of actual program participation or personal achievements. Different members of the study team conducted the coaching sessions and the assessments to reduce social desirability. Moreover, interviewers who assessed self-reported physical activity were blinded towards group allocation [1].
Finally, the lack of established cut-off values for wrist-worn ActiGraph counts is considered a major limitation. The wrist assessment and the analysis of the data based on exploratory cut-off values were considered most appropriate for the remote setting and the scope of the present study. However, as previously discussed, absolute values of objectively assessed physical activity need to be interpreted very cautiously. We therefore propose that wrist-worn ActiGraph data should be analyzed based on the raw data, applying R-package “GGIR” [177], in future studies.

6.3 Perspectives

The long-term objective of physical activity promotion is the implementation of evidence-based findings in practice [33,125]. Concerning the present PhD project, a first step in this direction has already been taken: Two Swiss health insurance companies (SWICA, EGK) are currently testing the implementation of the coaching intervention. These pilot projects will reveal whether the findings made within the presented study can be repeated in a real world setting.

Health insurance agencies currently pay up to 600 CHF for fitness subscriptions as part of health promotion and disease prevention. Personal telephone coaching for health-relevant behavioral changes could provide an attractive alternative resulting in comparable and even more sustainable health benefits. This is why these two pilot projects are examining whether the coaching is effective, accepted by clients and financially feasible when practically implemented by health insurance companies. The SWICA health insurance company carries out the larger of the two pilot projects. One hundred and thirty participants (SWICA employees or their friends and families) are gradually introduced to health-relevant behavior changes by the coaches of the Movingcall study. In contrast to Movingcall, a healthier diet is sought in addition to increased physical activity. The coachings are initially conducted weekly and then with decreasing frequency over a period of one year. The second pilot project is carried out by the EGK health insurance company. Besides above mentioned objectives, this project analyzes how much the clients would pay for a coaching and whether a shorter intervention period with fewer conversations achieves positive effects too.

If a telephone-based health coaching will be offered to a broad population in future, coaches with the required qualifications for personal health coaching are needed. In order to educate and train such coaches, a Certificate of Advanced Studies (CAS) named “Personal Health Coach” has now been approved at the Medical Faculty of the University of Basel. The contents of the CAS are based on the training for the coaches developed within this PhD project. BCTs and their application, knowledge on health behavior, as well as competencies in the area of coaching and conversation are taught within the CAS. In addition to promoting physical activity, the CAS focuses on a healthy diet and on stress reduction. The focus is not only on inactive adults but also on individuals with clinical conditions (e.g. diabetes, overweight). The contents of the training and the CAS were also included in the bachelor studies of sports students at the Department of Sport, Exercise and Health. A new seminar series on “Personal Health Coaching” was introduced in 2019.

Effective health prevention requires the involvement of industry, politics as well as the health care system [30]. The described coaching might also contribute to this vision of health prevention in industry. This is why a startup was founded based on this PhD project. The recently founded SaltuaCoach AG aims to implement a personal health coaching in cooperation with various partners. To date, health prevention and accordingly health related behavior changes are frequently perceived as a task for general practitioners. However, doctors often lack the time, the financial remuneration for this additional task and the knowledge in the field of health-relevant behavior change [178,179]. Accordingly, there is a need for support of individuals by experts in the field of behavior change, exercise, nutrition and stress management [180]. According to our vision, a partially personal and partially digitally communicated health coaching could become a method to support preventative health decisions and corresponding lifestyle related behavior changes. This applies to individuals in different life phases from children to the elderly.

Future research projects should broaden the evidence on efficacious intervention components for remote physical activity promotion in different populations. Considering an adult population, and

thereby the focus of this thesis, patients with non-communicable diseases should be considered in particular. Lifestyle-related behavior changes are essential in their treatment but especially these individuals are often confronted with many obstacles to behavior change [181-184].

One target group are patients with a depressive disorder. During hospitalization, physical activity is a therapeutic component, as patients benefit from its antidepressant effect [185]. However, patients frequently encounter difficulties in maintaining their activities after leaving the clinic [186,187]. The Department of Sport, Exercise and Health of the University of Basel is currently conducting a large study to investigate the impact of physical activity coaching on the physical activity level, depression as well as cardiovascular health risk markers of these patients [188]. The study is funded by the Swiss National Science Foundation and investigates 334 participants form four psychiatric clinics. The intervention begins with three face-to-face meetings based on the MoVo-LISA (LISA = Lifestyle-Integrated Sport Activity) concept [189] during the inpatient stay. Subsequently, telephone-based coaching, similar to the procedure in this PhD project, is conducted over the course of 12 months [188].

Patients with type 2 diabetes are another target group. Lifestyle-related physical activity and dietary changes are particularly effective in diabetes [190-192]. Therefore, the analysis of an adapted telephone coaching in a large study is planned. A pilot project in preparation of this study has already shown a high acceptance of telephone support by these patients. Recruiting the participants was, however, more difficult compared to the study Movingcall.

Occupational health promotion represents an opportunity to reach persons with specific risk factors. During recent years, there has been growing evidence that long periods of sitting represent an independent health risk [193]. Thus, individuals with a sedentary workday could be supported in achieving more physical activity and shorter sitting time in everyday life. Accordingly, future studies should also assess the frequency and duration of sedentary periods [194,195]. In addition, occupational health promotion could be used to reach individuals with a lower socio-economic status, which has been shown to be related with an increased risk of lifestyle-related diseases [196]. In the case of labor-intense work settings, one-sided movement patterns would have to be taken into account. Furthermore, these individuals frequently face specific challenges in the areas of healthy eating and stress reduction [197], where financial and cultural aspects should be taken considered.

With regard to effective intervention strategies, future research and implementation projects should examine various aspects, which this PhD project could not answer.

- If the remote setting no longer has to be strictly adhered to, it would be interesting to assess health relevant outcomes of behavior, such as fitness or body weight, beyond the sole physical activity behavior.
- The required density of telephone contacts as well as the effective duration of the intervention should be identified. The experiences of this project suggest an individually tailored procedure. However, it would be interesting to gain knowledge about a dose-response relationship between intervention density/duration and behavior change.
- Furthermore, future projects should analyze the maintenance of behavior changes after an even longer (e.g. two years) follow-up period during which the participants are not contacted.
- The cost-effectiveness of telephone coaching should also be analyzed in a next step [125]. Particularly for health insurance companies, financial savings could be a central argument for the broad implementation of prevention programs. There are some studies that demonstrated

the cost-effectiveness of patient coaching [68] however, the potential financial savings of preventative health coaching remains unknown.

- Furthermore, the question arises whether it is reasonable to change several health behaviors (e.g. stop smoking, change in diet, stress reduction) simultaneously. Do combined behavioral changes lead to overload or do participants benefit from taught strategies that work across behaviors? So far, the evidence is not very consistent [198], but the combination of energy-related behaviors seems reasonable [40,41].
- The most effective BCTs should be examined further to identify effective intervention options [47]. In order to better understand behavioral changes, the examination of theoretically founded working mechanisms should proceed [125].
- Furthermore, the effectiveness of additional intervention components, such as social interaction and support among participants, additional face-to-face interactions or personal training sessions might be analyzed.
- Finally, with regard to the delivery mode, future projects should analyze how interventions can be technically simplified and automated while maintaining their long-term attractiveness by involving a personal relationship. The effectiveness of a partly technically and partly personally delivered coaching should be investigated. Thereby, the rapidly advancing technical development will certainly open up exciting possibilities for a simplified interaction between coach and coachee.

6.4 Conclusion

There is a global call for action against the so-called pandemic of physical inactivity [5,30,199]. European strategy plans on the prevention of non-communicable diseases specify “the promotion of physical activity in adults as part of daily life, including during transport, at the workplace, as recreation and through the health-care system” as a key objective [200]. Increased physical activity levels not only bear the potential to reduce the burden of non-communicable diseases but also to lower the health care costs and to improve the quality of life of concerned individuals [13]. Thus, effective physical activity promotion programs that help individuals to overcome their barriers for regular physical activity are needed. Thereby personalized procedures and the targeted use of advanced technology are becoming more and more important [72,201]. These programs have the potential to be implemented by health care providers or prevention organizations [65]. Against this background the present PhD project contributes to the evidence on how insufficiently active adults can be supported in adopting a physically active lifestyle. The short and long-term effect of telephone coaching with and without SMS prompting were compared in a three-armed randomized controlled trial.

In conclusion, the Movingcall study showed that telephone coaching based on established BCTs induced higher increases in physical activity levels compared to a minimal intervention. Additional SMS prompts did not lead to a further increase in physical activity levels. Directly after the end of the coaching intervention, self-reported as well as objectively assessed physical activity had increased. After a six-month follow-up period, self-reported physical activity levels were maintained, whereas objectively assessed physical activity levels returned to baseline. As objectively assessed physical activity levels decreased below baseline in the control group, group differences in favor of the two coaching groups persisted. The analysis of working mechanisms revealed that the BCT based coaching intervention showed a positive effect on psychosocial determinants of physical activity. Against our expectations, changes in these psychosocial determinants were very weakly associated with actual changes in self-reported or objectively assessed physical activity.

The coaching concept developed as part of this PhD is already being applied in follow-up and implementation projects. These and future projects will further reveal how technologically supported remote physical activity promotion can be implemented in practice.

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Appendix A: Contributors

The author of the dissertation led the project "Movigncall" from planning to publication. This included compiling the study, developing the content of the physical activity promotion program, writing the ethical proposal, setting up and training a team of coaches, recruiting study participants, leading the team of coaches and coordinating the implementation of the interventions, coordinating the assessment periods, collecting data and conducting statistical analysis, writing the drafts of the manuscripts and finally publishing the papers as first author. In addition to the author, four experienced scientists contributed as supervisors to the success of the project. Their contributions to the publications as well as to the project in general are specified below.

Prof. Dr. Lukas Zahner: Was the strategic study manager and had overall responsibility for the project. He generated the initial idea of a remote physical activity promotion program, provided the funding for the PhD project, participated in the study design and supported the compiling of the study, helped to recruit participants through his personal and professional network, supervised Master thesis and reviewed the drafts of the manuscripts of all publications.
Prof. Dr. Lars Donath: Participated in the study design and supervised and supported the compiling of the study, advised on the setup of the study procedures, conducted the sample size calculation, reviewed the ethical proposal, advised on statistical analysis, critically revised the first versions of the manuscripts of the first and second publications and reviewed the drafts of the manuscripts of all publications.
Prof. Dr. Markus Gerber: Participated in the study design and supported the compiling of the study, advised the selection of outcome measures, supported the statistical analysis of the third publication, critically revised the first version of the manuscript of the third publication and reviewed the drafts of the manuscripts of all publications.
PD. Dr. Oliver Faude: Participated in the study design and supported the compiling of the study, advised on statistical analysis and reviewed the drafts of the manuscripts of all publications.

Further, a large team of sport and psychology students realized the implementation of the project. These were **Angela Cramieri, Fabian Göring, Kimberly Zwygart, Michele Lütolf, Sara Krüger, Timon Mikula, Jan-Niklas Kreppke, Katrin Jaeggi, Alain Kaiser, Valerio Weber, Virginie Thommen, Yannik Rösli, Eliane Keller, Anja Amann, Billie Stump, Lya Feitknecht, Maria Thomann, Sabrina Frutig, Sandro Roniger, Selina Frutuoso Ferreira, Jenny Ndoyi, Florian Droux, Natascha Krickel, Sarah Müller, Tonja Krenmayr, Vanessa Alvarado, Jan Fiechter, Lilja Rhodius, Alexandra Toscanelli and Eveline Schärli.** As part of their Master or Bachelor theses, leaning contracts, internships or as tutorial assistants they coached the participants, helped to develop the program and/or supported the data collection (i.e. conducted interviews, sent accelerometers, processed accelerometer data, communicated with participants).

Finally, **Robyn Cody** revised the grammar and punctuation of this thesis and all included publications.

Appendix B: Curriculum vitae

Name	Xenia Johanna Fischer
E-Mail	xenia.fischer@unibas.ch

Education and professional degrees

Since 05.2015	**Doctoral Candidate,** *Department of Sport, Exercise and Health, University of Basel*
09.2012 - 12.2014	**Master of Science in Exercise and Health Science**, *University of Basel* Major fields of study: Prevention, rehabilitation and health promotion through physical activity Final grade 5.5
09.2008 - 08.2011	**Bachelor of Science in Sport Science**, *University of Bern* Minor Psychology, Final grade 5.5
2007	**Matura,** *Kantonsschule Rychenberg, Winterthur*

Professional background

Since 05.2015 **Research associate***, Department of Sport, Exercise and Health, University of Basel*

- Project management: Planning, implementation and evaluation of remote physical activity promotion program
- Assembling, training and leading of an interdisciplinary team
- Supervising thesis and internships
- Giving lectures, educating coaches for personal physical activity counselling
- Writing peer-reviewed scientific articles
- Development of a CAS (certificate of advanced studies) for personal health coaching
- Presentations at international conferences

06.2015 - 02.2016 **Pilates instructor**, *Unisport, University of Basel*

12.2014 - 02.2015	**Performance diagnostics** (Internship 80%) *crossklinik Basel, Swiss Olympic Medical Center* – Lactate threshold, spiroergometry and strength measurement in athletes
8.2011 - 1.2014	**Movement therapy in psychiatric clinic** (internship and employment, 50 - 80%, with interruptions) *Clienia Schlössli, Oetwil am See* – Group lessons and individual therapies in patients with various mental diseases
10.2010 - 08.2011	**Tutorial assistant,** *Institute of Sport Science, University of Bern*

Additional skills

Languages	German	native speaker
	English	proficient
	Italian and French	good
IT	Profound knowledge in MS-Office	
	Good knowledge in statistic program STATA and SPSS	

Publications

PhD relevant

Fischer, X.; Donath, L.; Zwygart, K.; Gerber, M.; Faude, O.; Zahner, L. Coaching and prompting for remote physical activity promotion: Study protocol of a three-arm randomized controlled trial (movingcall). *Int. J. Environ. Res. Public Health.* 2019, *16*, 331.

Fischer, X.; Kreppke, J.; Zahner, L.; Gerber, M.; Faude, O.; Donath, L. Telephone-based coaching and prompting for physical activity: Short- and long-term findings of a randomized controlled trial (movingcall). *Int. J. Environ. Res. Public Health.* 2019, *16*, 2626.

Fischer, X.; Donath, L.; Zahner, L.; Faude, O.; Gerber, M. Exploring psychosocial mediators of remote physical activity counselling: A secondary analysis of data from a 1-year randomized control trial (movingcall). Under review.

Other contributions

Gerber, M.; Beck, J.; Brand, S.; Cody, R.; Donath, L.; Eckert, A.; Faude, O.; Fischer, X.; Hatzinger, M.; Holsboer-Trachsler, E.*, et al.* The impact of lifestyle physical activity counselling in in-patients with major depressive disorders on physical activity, cardiorespiratory fitness, depression, and cardiovascular health risk markers: Study protocol for a randomized controlled trial. *Trials.* 2019, *20*, 367.

Schilling, R.; Scharli, E.; Fischer, X.; Donath, L.; Faude, O.; Brand, S.; Puhse, U.; Zahner, L.; Rosenbaum, S.; Ward, P.B.*, et al.* The utility of two interview-based physical activity questionnaires in healthy young adults: Comparison with accelerometer data. *PLoS One.* 2018, *13*, e0203525.

Teaching experiences

Since 2016	Seminar "Personal Health Coaching", adaption of teaching contents and lectures on: Personal training, personal coaching, health behavior, behavior change theory and techniques, individual tailoring, assessment of psycho-social determinants
2016 - 2018	Organization of the course "Trainingswissenschaft: Schwerpunkt Leistungsdiagnostik 1 and 2" and lecture on endurance training
2016 and 2017	"Training in Fitness- und Wellnesseinrichtungen", lecture and practical unite on endurance training in fitness centers
2017	"Entwicklung der körperlichen Leistungsfähigkeit in der ersten Lebenshälfte", lecture on „Bewegungs- und Sportförderung bei Berufstätigen"

Supervision of scientific projects

Master thesis	Alain Kaiser, Angela Crameri, Fabian Göring, Felicitas Zuber, Jan-Niklas Kreppke, Judith Matter, Katrin Jaeggi, Kimberly Zwygart, Michèle Lütolf, Olivia Berner, Sara Krüger, Timon Mikula
Bachelor thesis	Anja Amann, Eliane Keller, Pascal Mäder, Sarah Müller, Valerio Weber, Virginie Thommen, Yannik Rösli

Conference contributions

Oral presentation	European Collage of Sport Science (ECSS), 24th annual congress, *Prag*
	Young investigator award final, 11th annual conference of the Swiss Society of Sport Science (SGS) 2019, *Fribourg*
	10th annual conference of the Swiss Society of Sport Science (SGS) 2018, *Magglingen*
	Swiss Public Health Conference 2017, *Basel*
Poster presentation	7th International Society for Physical Activity and Health Congress (ISPAH) 2018, *London*
	Centre for Behaviour Change (CBC) Conference 2018 - Behaviour Change for Health: Digital and Beyond, *London*
	9th annual conference of the Swiss Society of Sport Science (SGS) 2017, *Zürich*

Memberships

Since 2015	Swiss School of Public Health (SSPH+)
Since 2016	Sportwissenschaftliche Gesellschaft der Schweiz (SGS)
Since 2017	Member of European College of Sport Science (ECSS)

Graduate education

Course	Institution	ECTS
Methodological and organizational competences		
Project management for researchers*, Dimitrije Krstic*	University of Basel	1
Fundraising and proposal writing, *Dr. Andrea Degen*	University of Basel	1
Physical activity measurement seminar, *Dr. Soren Brage Kate Westgate, Stef Hollidge*	University of Cambridge	2
Systematic reviews and meta-analysis: A practical approach, *Prof. Dr. Matthias Egger*	SSPH+ ,ISPM, Bern	1
Writing a journal article and getting it published, *Prof. Dr. Claudia Kuehni*	SSPH+, ISPM, Bern	1
Qualitative health research: Introductory module, *Prof. Dr. Brigit Obrist*	SSPH+, University of Basel	1
Behaviour change		
CBC summer school: Behavior change - principles and practice, *Prof. Dr. Susan Michie and Prof. Dr. Robert West*	University College London	2
Advanced CBC summer school: Influencing motivation, changing behavior in complex systems and evaluating behavior change interventions, *Prof. Susan Michie, Prof. Robert West, Dr. Lou Atins, Dr. Paul Chadwick*	University College London	2
New technologies and changing behavior, *Prof. Dr. Lorenzo Chiari, Prof. Dr. Beatrix Vereijken*	PreventIT Summer School; University Residential Centre of Bertinoro	2
mHealth: Mobile communication for behavior change, *Prof. Dr. Suzanne Suggs*	Summer School in Public Health Policy, Economics and Management	1

Health financing policies, health system performance and obstacles to universal coverage, *Dr. David B Evans, Dr. Fabrizio Tediosi, Dr. Gabriela Flores*	Summer School in Public Health Policy, Economics and Management	1
Statistics		
Seminars in applied statistics 1 – 3, *Dr. Andrea Hans Meyer*	University of Basel	6
Introduction to the statistical software R, *Dr. Jan Hattendorf*	SSPH+, STPH, Basel	1
Introduction to the statistical software Stata, *Dr. Adrian Spoerri*	SSPH+, ISPM, Bern	1
Statistical analysis with missing data using multiple imputation and inverse probability weighting, *Prof. dr. James Carpenter and Prof. Dr. Marcel Zwahlen*	Swiss Epidemiology Winter School	1
Multilevel modeling: Analysis of clustered data, *Prof. Dr. Martin Röösli*	SSPH+, STPH, Basel	1
Start-up		
Innosuisse entrepreneurship training - business concept, *Christian Schneider*	University of Basel, Innovation Space	2
Total ECTS		**27**