Abstract

Lack of daily physical activity and the associated low cardiovascular fitness levels in addition to inferior muscle and skeletal strength has become a major societal challenge and a threat to public health. It is, therefore, relevant to identify effective exercise modalities that can motivate people to become and remain physically active. Team sports may, as exemplified by recreational football, provide certain advantages related to physiological and motivational aspects, and with validated health-promoting adaptations, team handball could be another promising alternative to traditional exercise-training programmes. However, the physiological effectiveness and the specific impact on various health parameters must first be demonstrated in RCT studies to maximize clinical and practical impact. Team handball is a technically- and tactically-demanding activity, but it may also be organized as small-sided team handball, appealing to a broader segment of the population. The purpose of the present project was to investigate whether small-sided team handball is a feasible activity for untrained people with and without prior team handball experience, and whether the team sport has the qualities to positively impact on a number of physiological parameters, including cardiovascular, musculoskeletal, and metabolic fitness.

Three randomized controlled studies were conducted in untrained young adult women and men (studies I and II) and in overweight premenopausal women (study III) for training periods of 12 and 16 weeks, respectively. In studies I and II, 40 and 32 participants were stratified by cardiorespiratory fitness (VO2max) and fat percentage and randomly allocated to either small-sided team handball training or a non-training control group. In study III, the participants were randomly allocated either to one of two team handball groups, one without and one with prior team handball experience or to a control group comprising both unexperienced and experienced
participants. In studies I and II, video-based time-motion analyses were performed in combination with heart rate measurements during the training interventions. All studies included pre- and post-testing of physical exercise capacity and physiological adaptations with assessment of VO$_{2\text{max}}$, body composition, bone mineral density in proximal femur (proximal femur BMD), bone markers, cholesterol, resting heart rate, blood pressure, intermittent exercise performance, as well as evaluation of psycho-physical well-being and motivational questionnaires. Additional measurements of oxidative enzymes, including citrate synthase (CS) and 3-hydroxacyl-CoA dehydrogenase (HAD) activity, as well as echocardiographic parameters, were carried out in studies II and III, respectively.

Analyses of the training revealed that all studies included periods with intense exercise, irrespective of experience and sex, as indicated by average heart rates of ~85% of maximal, and >30% of total training time in the highest intensity zone: heart rate >90%HR$_{\text{max}}$. Furthermore, the activity patterns in studies I and II illustrated a high number of various high-intensity actions, such as high-intensity running, accelerations, decelerations, rapid turns, side-steps, jumps and backward-running, in combination with a high level of ball possession in relation to shots and passes. The untrained young adult men in study II achieved large improvements during the 12-week training period with marked effects in VO$_{2\text{max}}$, proximal femur BMD, body composition, physical performance, and CS activity. For the young adult women in study I, adaptations were confined to increased muscle mass, higher proximal femur BMD and improved physical performance without significant changes in VO$_{2\text{max}}$. In study III, both team handball groups increased proximal femur BMD with training, but only the group without prior team handball experience displayed higher VO$_{2\text{max}}$ and lower total fat mass and android fat mass after 16 weeks of small-sided team handball. The increase in proximal femur BMD was associated with elevations
in formation bone markers procollagen type-1 amino-terminal propeptide (P1NP) and osteocalcin, for all three studies. Furthermore, it was observed that mental energy and intrinsic motivation to accomplish were higher after the training period in study I.

In conclusion, the three studies demonstrated, that small-sided team handball has significant effects on a range of physiological parameters of relevance for health, including VO\textsubscript{2max}, body composition, and proximal femur BMD. The osteogenic response was consistent across all three studies, which may relate to the intermittent nature of team handball with numerous intense, high-impact actions. Elevated cardiorespiratory fitness was observed for the young adult men in study II and for the overweight premenopausal women without prior team handball experience in study III, while there were no improvements in VO\textsubscript{2max} for young adult women in study I or for overweight premenopausal women with prior team handball experience in study III, although the training intensity was comparable for all four groups. Interestingly, study III revealed that prior experience with team handball was not a prerequisite for completing high-intense training and improving physiological parameters. Thus, small-sided team handball is a high-intensity activity with a high level of involvement that can lead to widespread health benefits and a positive impact on mental energy and intrinsic motivation.