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Title: Effects of home confinement on intensity of physical activity during the COVID-19 outbreak in team handball according to gender, competition level and playing position: A Worldwide Study.

Running head: Team handball during COVID-19 Outbreak

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ABSTRACT

Because of the COVID-19 pandemic, several restrictions have been implemented due to public health recommendations and subsequent government directives. Restrictions primarily include social distancing and home confinement which have serious implications for competitive athletes, and this research area is understandably scarce. As such, the aim of this investigation was to examine the effects of home confinement on intensity of physical activity (PA) during the COVID-19 outbreak in Team Handball. A total of 1359 handball players volunteered for the present investigation (age: 22.8 ± 6.0 years; body mass: 78.1 ± 14.9 kg; height: 1.76 ± 0.10 m; BMI: 25.0 ± 3.82 kg/m²). Participants answered an online version of the International Physical Activity Questionnaire (IPAQ) through Google Forms. Five research organizations administered the survey in Europe, Western Asia and the North Africa in several languages. Participants were asked to consider “before” and “during” confinement and conditions. The COVID-19 home confinement had a negative effect on PA intensity (vigorous, moderate, walking and overall). The largest changes across all parameters were detected for the sum parameter “all physical activity”. MET-minutes/week (η²=0.903) and minutes/week were significantly decreased (η²=0.861) compared before and during confinement. Additionally, daily sitting time significantly (p<0.001, η²=0.669) increased from 2.7 to 5.0 h per weekday. For gender, level of handball league, and playing position, no significant differences (group and interaction effects) were observed. However, for all parameters, significant time effects were observed. The largest change (in terms of η²) in PA behavior for was found for walking (minutes per day: η²=0.755), with males displaying the greatest decrease (from 62.1 ± 10.6 to 29.9 ± 13.5 minutes per weekday; d=2.67). In terms of magnitude, the difference between genders regarding sitting was the greatest (difference in d=1.20). In conclusion, whilst COVID-19 measures are essential to preserve public health, PA was
compromised as a result of these interventions. COVID-19 confinement led to a large decrease in
PA regardless of activity level, gender, and handball competition level, worldwide.

Keywords: COVID-19; home confinement; team handball; physical activity; stress; lockdown.
INTRODUCTION

Since late December 2019, the world seems to have come to a standstill with the Coronavirus disease 2019 (COVID-19) outbreak. In the face of the ongoing pandemic, public health authorities and governments have enforced increasingly restrictive recommendations and escalation measures, including self-isolation, quarantine, and even lockdowns of entire communities and territories.

These restrictions are necessary to curb infection rates, yet such limitations may compromise normal daily activities, traveling, physical activity (PA), and adherence to exercise as a result of gyms being closed, group gatherings being forbidden, and increased social distancing (Hossain et al., 2020; Ammar et al., 2020a). In addition to the previously mentioned measures, curfews have been implemented in some countries which limits opportunities for outdoor activities. These measures have demonstrably positive short-term effects on virus transmission but may negatively affect population health, via decreased physical fitness, known to influence immune function. This effect may exert more severe long-term effects associated with immunological and cardiopulmonary functioning, and the ability to cope with infection (Bloch et al., 2020; Steinacker et al., 2020).

The mandated restrictions concerning outdoor activities, including the regular practice of exercise and PA during the COVID-19 outbreak are leading to reductions in exercise and PA. In fact, even athletes that complete strength and endurance training programs at home have suffered from reduced aerobic capacity (Fikenzer et al., 2020). Consequently, this may contribute to anxiety, depression, mental health distress, and common chronic health diseases (Ammar et al., 2020a; Arora et al., 2020; Hakansson et al., 2020; Schuch et al., 2020). These psychological issues exert an influence on training and recovery in athletes (Mon-Lopez et al., 2020), which may lead
to inferior performance compared to pre-lockdown. Concerning PA, frequency and duration would expectedly decrease in physically active people as a result of inability to access gyms and health clubs, and reduced need for active transport (i.e. cycling or walking to work) (Ammar et al., 2020a; Lesser et al., 2020). Taken together, the pandemic exerts negative patterns on PA within the general population but the effect on more competitive, and thus highly active individuals is less known. As a result of this paucity of data, and our previous experience in team handball, we sought to gain an understanding of the COVID-19 restrictions on PA in team handball players (Mon-López et al., 2020).

Individual characteristics determine effects of training modification during the quarantine (Mon-López et al., 2020; Pillay et al., 2020), and subsequently there have been reductions in some components of fitness to a greater extent than others. Previous studies have reported changes in jumping performance, throwing velocity, maximum muscular strength, and upper and lower limb power during a handball season (Marques et al., 2006; Granados et al., 2008). Moreover, it is conceivable that a lack of team training and official competitions in team sports may have decreased communication between players and coaching staff, resulting in inadequate training programming (Silva et al., 2016). Therefore, in the context of COVID-19, public health measures such as isolation, curfews, and lockdowns could have resulted in partial or total reversal of the training adaptations (i.e. ‘detraining’; Mujika et al., 2000; Mon-López et al., 2020).

Considering the profound impact COVID-19 has had on working conditions of athletes, the present study considered handball players worldwide from various leagues, competition levels, and playing positions. The study aimed to rapidly assess how COVID-19 may have affected these groups of players during the ongoing crisis and its major consequences on society. Specifically, we aimed to determine changes since the COVID-19 outbreak and how PA of handball players
compared to before the pandemic using questionnaires. Our primary hypothesis was that PA would have decreased as a result of the restrictions. A secondary hypothesis was that individuals at a higher competition level and males would have experienced a greater reduced in PA than individuals at a lower competition level, and women.

MATERIALS AND METHODS

An important criterion for the selection of questionnaires was the proof and evidence of validity and reliability (Graig et al., 2003; Lee et al., 2011). The International Physical Activity Questionnaire Short Form (IPAQ-SF) is a multicounty electronic survey designed to assess changes in PA, previously outlined as valid in this context (Ammar et al., 2020a; Ammar et al., 2020b; Ammar et al., 2020c). The IPAQ-SF, was opened on 21st May 2020, following testing by the project steering group for 7 days. The IPAQ-SF was disseminated worldwide on 27th June 2020 via six research organizations from Europe, North Africa, Western Asia and North America. However, all measures were collected on the same day, to avoid any bias in the study, considering the constantly evolving situation of the pandemic.

The IPAQ-SF was officially translated and administered in English, German, French, Arabic, and Japanese. The survey included 25 questions on gender, demographic information (e.g., age, body mass and height), level competition, handball league, playing position, playing experience, competitions per years, health status, PA (e.g., vigorous, moderate and walking activity). All PA and sitting time related questions were presented in a differential format, to be answered directly in sequence regarding “before” and “during” confinement conditions (Ammar et al., 2020a; Ammar et al., 2020b; Ammar et al., 2020c). A total number of items were included in the IPAQ-SF online survey in a differential format (i.e., each item or question requested two answers, one
regarding the period before and the other regarding the period during confinement and participants were guided to compare the situations (Ammar et al., 2020a; Ammar et al., 2020b; Ammar et al., 2020c). Once the deadline for admitting surveys had passed, answers were reviewed to remove contradictory responses (checking congruence between data provided by players) or repeated (checking two or more submissions with the same responses in a short period of time), deleting one response from the database. Given the large number of questions included, the present paper focuses on the IPAQ-SF as a brief crisis-oriented tool. Participants signed an informed consent form before completing the survey. The study was conducted according to the Declaration of Helsinki and was approved by the university’s institutional review board (QU-IRB 1350EA-2020) for the local participants.

**Sample Size**

The sample size was calculated according to the following predictive equation (Whitley and Ball, 2002).

\[
N = \frac{(Z_{\alpha/2}^2 p q)}{\Delta^2}
\]  

(1)

N: number of needed participants,

\(Z_{\alpha/2}\): two-tailed normal variance for type 1 error,

p: change in % from “before” to “during” confinement,

q: equal to “1 - p” and \(\Delta\): accuracy; where “n” was the number of needed participants,

“\(Z_{\alpha/2}\)” was the two-tailed normal deviate for type 1 error (\(Z_{\alpha/2} = 1.96\) for 95% level of significance),
“q” was equal to “1 - p”,

“Δ” was the accuracy (=3%), and

“p” was the percentage of change in social participation from “before” to “during” confinement period.

Comparable to Ammar et al. (2020d), the “p” was from a recently published study (Zhang and Ma, 2020) was used. Zhang and Ma (2020) examined the immediate effects of the COVID-19 pandemic on mental health and quality of life. Based on these findings, it appeared that 57.8% (p=0.578) of subjects experienced an increase in shared feelings with family members (Zhang and Ma, 2020). Consequently, the calculated sample size was n=1041. We recruited our sample size assuming a dropout rate of 40% (n=416). Therefore, we invited 1,500 subjects to participate.

**Survey Development Promotion and Distribution**

A steering group of scientists and academics (in the fields of human sciences, sport science, and computer science) designed the electronic survey at the University of Qatar (where the principal investigator was based). Thereafter, the survey was reviewed and edited by >35 colleagues and experts before being disseminated via the Google platform (online). Members of the consortium distributed the link to the survey via several methods: e-mail, official faculty pages, ResearchGate™, LinkedIn™, and other social media platforms such as Facebook™, WhatsApp™, and Twitter™. The general public assisted in the dissemination through promotion of the survey within their networks. In total, the uniform resource locator (URL) of the online survey was sent to 1500 potential participants, of which 1359 returned valid questionnaires and were included in analysis (participation rate of 91%). The description of conditions of lockdown in countries of participants is displayed in Table 1.
The survey included an introductory page describing the background and the aims of the survey, the consortium, ethics information for participants, and the option to choose one of five available languages (English, German, French, Arabic, and Japanese). The inclusion criterion was that participants were handball players aged 18 years or older and in good health. No restrictions in terms of playing level, categories, or playing position were made. Exclusion criteria included the existence of any chronic disease or orthopedic condition that might interfere with the participation in the study, and players with cognitive decline. Before completing the survey, individuals voluntarily consented to anonymously participate in this study.

**Data Privacy and Consent of Participation**

Participants were assured data would be used solely for the research purpose during informed consent gathering. Responses were anonymous in line with Google’s privacy policy (https://policies.google.com/privacy?hl=en). Participants were informed if they wished to withdraw, responses would not be saved or incorporated into analyses. Responses were confirmed once participants clicked 'submit' (Ammar et al., 2020d).

**International Physical Activity Questionnaire Short Form (IPAQ-SF)**

In line with the IPAQ-SF guidance, the summation from each item (i.e. vigorous intensity, moderate intensity, walking) was used to estimate total PA time per week (Graig et al., 2003; Lee et al., 2011). Weekly PA in MET-min·week$^{-1}$ was calculated by addition of each item multiplied by its respective MET value. The original MT values (original IPAQ) based on the official IPAQ guidelines for young and middle-aged adult (18–65 years old) were used: vigorous PA = 8.0 METs, moderate PA = 4.0 METs and walking = 3.3 METs. Additionally, we added total PA (sum of
vigorous intensity, moderate intensity, and walking activities) as a fourth item and sitting time as a fifth item.
**Statistical Analyses**

All statistical analyses were performed using the “Statistical Package for Social Sciences” (SPSS version 25.0 for Windows, SPSS Inc., IBM, Armonk, NY, USA). Following confirmation of parametricity, data were analysed using two-way analyses of variance (ANOVAs). 'Time' was considered the within-subject factor, and between-subject factors were 'gender' or 'handball league' depending on the analysis being conducted. Subsequently, pairwise effect size was calculated for each parameter by dividing the mean difference in variable by the pooled standard deviation, and interpreted as small (d<0.5), moderate effects (d≥0.5), and large effects (d>0.8) (Cohen, 1988). A positive effect size represents an improvement, and a negative value represents a decrement in said variable. Percentage changes were calculated as ([post-confinement value - pre-confinement value]/pre-confinement value) x 100. Differences were considered as significant if p< 0.05, partial eta-squared (η²) >0.10 and the effect size (d) was ≥0.8 (Richardson, 2011). Data are reported as means ± standard deviations (SD).
RESULTS

Recruitment of the sample

1359 from 1500 invited participants responded. 85% (1153/1359) participants were recruited in Asia (Table 2), whilst the highest number of investigated subjects were in Japan (n=758, 56%), Kuwait (n=102, 8%), and Saudi Arabia (n=97, 7%).

Level of handball league

29% (n=391) participants played in the first league (Table 2), whilst most (46%) players played in the second league (n=631). Only 25% of players played in the third or fourth league (n=337). For all PA variables, no effects of playing standard (handball league) or interaction (handball league x time) were observed (rejection of our primary hypothesis). Two thirds of the subjects were male (n=901) and age varied from 18 to 45 years (mean age: 22.8 years; Table 3).

Gender comparison

Time effects for PA variables (vigorous or moderate physical activities and walking or sitting) ranged from $\eta^2_p=0.48$ (walking days/walk for at least 10 minutes) to $\eta^2_p=0.82$ (vigorous MET-minutes per week). No significant differences (group effects or interaction effect) between male and female were observed (Table 4). Significant time effects were observed ubiquitously.

A large change in PA was observed for vigorous MET-minutes per week ($\eta^2_p=0.82$). Males showed a greater decrease in this parameter (from 2492 ± 654 to 740 ± 500 MET-minutes/week; $d=3.04$) and the difference in effect size between genders was $d=1.15$. The smallest reduction over
time was observed for walking ($\eta^2_p=0.48$) and males' and females' effect size were similar
($d_{female}=1.14$, $d_{male}=1.39$). The largest change in PA parameters was detected for “all physical
activity” whereby the energy expenditure (MET-minutes/week: $\eta^2_p=0.90$) was significantly
decreased compared during, compared to before, confinement.

Playing position ($p=0.083$, $\eta^2_p=0.01$), gender ($p=0.137$, $\eta^2_p=0.00$), and level of handball league
($p=0.001$, $\eta^2_p=0.01$; Figure 1a-c) did not influence sitting time.

***Figure 1a-c***

PA changes were large in all playing positions (Figure 1a) and were similar in magnitude
(goalkeepers $d=1.83$, backs $d=2.00$). Similar results were observed for the influence of level of
handball league (Figure 1c). The effects ranged from $d=1.82$ (second division) to $d=2.07$ (third
division). Regarding gender (Figure 1b), males showed a markedly greater reduction ($d=2.44$) than
females ($d=1.24$).
RESULTS

Results presented here suggest COVID-19 had a significant negative effect on all intensities of PA in competitive handball players regardless of gender, level of handball league, and playing position. Moreover, significant increases in sitting time were observed in all participants. Large reductions in PA at medium and vigorous intensity were observed, and this may reflect the subtraction of handball team training. A comprehensive understanding of implications of these effects is yet to be fully elucidated but we propose reduced fitness following confinement is a likely outcome, and an issue coaches and practitioners should be cognizant of.

Main findings

Home confinement by COVID-19 caused a significant decrease in the amount of walking per week and an increase in sitting time, which reflected the PA in daily life. In addition, the amount of PA at vigorous and moderate intensity, which mostly reflected PA in handball training for handball players, was also decreased by COVID-19 home confinement.

Results indicate that COVID-19-induced home confinement significantly affected not only daily life activities but also PA at moderate and vigorous intensity, which is essential for handball players to maintain and improve their physiological capacities, and therefore performance as handball players at all levels of performance.

Impact upon daily life

PA exerts well documented and measured healthogenic effects and concomitantly there is clear evidence linking physical inactivity to non-communicable diseases (Lee et al., 2012). Many governmental agencies have developed PA guidelines as a positive measure for physical and
mental health (WHO, 2010; Tremblay et al., 2011; King et al., 2019), accentuating the importance of PA for public health.

In the present study, number of walking days for at least 10 minutes per week was decreased from 4.58 ± 1.57 days to 2.89 ± 1.40 days for women and from 4.38 ± 1.25 days to 2.67 ± 1.21 days for men with a decrease of about 40% in women and men. At the same time, the time of each walk decreased from 56.9 ± 13.0 minutes to 27.2 ± 12.2 minutes in women and from 62.1 ± 10.6 minutes to 29.9 ± 13.5 minutes in men, representing ~50% in both genders. Therefore, energy expenditure of walking per week decreased from 868 ± 364 MET-minutes/week to 266 ± 188 MET-minutes/week for women and from 896 ± 301 MET-minutes/week to 273 ± 192 MET-minutes/week in men. It is thought that walking PA is part of the activities of daily life, such as moving around the training facility and at work outside of handball training. Thus, the decrease of walking volume in our subjects may reflect an inactive habitual lifestyle. In addition, sitting time would also be considered an indicator of time is spent in the home. The sitting time on weekdays was increased from 2.87 ± 1.44 hours to 4.67 ± 1.47 hours in women and from 2.66 ± 1.08 hours to 5.20 ± 1.00 hours in men. These values corresponded to 1.6 time more sitting time in women and 2.0 more sitting time in men. Previous studies have reported healthy population increased time spent viewing television and social networking using smart phone and video games during COVID-19 home confinement (Ammar et al., 2020a; Pillay et al., 2020). Our results demonstrate that even athletes have changed their lifestyle to be less active during this pandemic.

Comparing walking time per week among athletes versus healthy general populations prior to COVID-19 home confinement, walking time per week was 2 times higher in our study than in a previous study (Ammar et al., 2020a). However, the difference in walking time per week between our study and the previous study became smaller during COVID-19 home confinement. Sitting
time on weekdays in this study was also 1.6 times and 2 times higher among women and men, respectively, than before COVID-19 home confinement. This increase in sitting time was not influenced by playing position, gender, and level of handball league, suggesting all handball players have been more sedentary as a result of COVID-19 measures.

According to the results of an international survey concerning effects of COVID-19 home confinement on PA in healthy populations, sitting time was increased 1.58 times compared to before COVID-19 home confinement (Ammar et al., 2020a). The degree of increase is smaller than the average value among women and men found in this study. Thus, the impact of physical inactivity in daily life due to COVID-19 home confinement may be greater in athletes than in the general healthy population. It is thought that the greater negative effect was likely due to athletes being more physically active in daily life before COVID-19 home confinement than the normative healthy population.

**Impact of COVID 19 on handball training**

Handball is characterized by repeated high-intensity actions such as jumping, sprinting, and changes of direction, interspersed by lower intensity periods (Hermassi et al., 2019; Bragazzi et al., 2020). In addition to the internal loads, body contact with opposition players increases neuromuscular load, and increases recovery requirements (Gallo et al., 2020).

Thus, it is important for daily handball training to simulate the game at vigorous and moderate intensity. In this study, frequency, time, and metabolic expenditure of moderate to vigorous PA per week was reduced during COVID-19 home confinement. In generally, handball players have handball training 4-5 times per week and training is 2-3 hours per session (Hermassi et al., 2019). Furthermore, they have one game a week, depending on the time of year (Hermassi et al., 2019).
In this study, we observed that frequency of PA per week (in time per day) at vigorous intensity decreased 49% in women and 57% in men, respectively, during COVID-19 home confinement, likely resulting in considerable reductions in fitness. Although we were unable to quantify reduction in fitness as a result of reduced moderate to vigorous PA, Fikenzer et al. (2020) reported the COVID-19 lockdown led to a reduction in aerobic capacity of elite handball players without team training, despite implementation of a home-based strength and endurance training program. Similarly, Mon-López et al. (2020) reported COVID-19 affected training load and recovery process and noted emotional intelligence could predict the change in training variables of top-level soccer players. The recent study of Mon-López et al. (2020) reported handball players reduced training intensity, training volume, which is concordant with the present investigation.

Regarding competition level, Mon-López et al. (2020) reported a greater training time reduction in professional handball players than in non-professionals, commensurate with the present study. Skoufas et al. (2008), who demonstrated that athletes with a higher competitive level reduced their training volume more than others during the off-season or non-competitive periods due to the higher initial levels of PA, found similar results.

Regarding gender, Mon-López et al. (2020) reported a greater reduction in training volume in men than in women during COVID-19, which is in accordance with Giustino et al. (2020). These findings do not agree with those presented here, as we found no gender or gender x time effects. At both measurement times, men tended to show a higher level of activity than the women. However, when gender and competitive level were considered together, the decrease in training volume was greater in professional female players than in professional male players. Mon-López et al. (2020) indicated this result could be biased by the presence of greater number of women in the professional handball category (47%) compared to the number of professional male handball.
players (38%). In fact, PA levels in professional female handball players before isolation were higher and the reduction greater. In this context, professional female athletes reduced their training volume more during quarantine (76%) than professional males (74%).

In some surveys investigating the impact of COVID-19 on training in elite and semi-elite athletes in South Africa (Pillay et al., 2020) and Italy (Giustino et al., 2020), vigorous and moderate intensity PA decreased during home confinement. In fact, the IOC's survey has reported many athletes have been unable to train effectively due to the lockdown caused by COVID-19, and cite this as a major problem for athletes (Survey Findings IOC). We observed a large impact of COVID-19 home confinement on moderate and vigorous intensity PA in athletes. Thus, we propose handball player had insufficient frequency, time, and intensity to sustain or improve physical function and performance during home confinement, and these individuals likely have experience a large reduction in fitness over this time period.

**Reasons of decreased PA at moderate and vigorous intensity**

In a survey of PA during lockdown in the Canadian adult population (Lesser et al., 2020), the time of PA at moderate and vigorous intensity of people with originally high activity (MVPA of 302 ± 186 minutes per week) was not decreased despite lockdown. Their physical activities at moderate and vigorous intensity consisted of individual outdoor exercise such as walking, running and cycling. In contrast, the amount of PA at moderate and vigorous intensity in handball players was significantly decreased in this study. The reason for this conflict in results could be the difference between individual PA for recreation and health promotion and competitive team sports (Mon-López et al., 2020a). People undertaking individual PA for recreation and health promotion may be able to continue the same exercise during lockdown performing outdoor activity such as walking, running and cycling whereas handball players and those involved in indoor team sports
may experience the greatest deleterious effect of confinement. It may be pragmatic to consider that COVID-19 quarantine has had effects at different levels (physical, physiological, psychological, and emotional) due to a change in the athletes’ daily lives and training habits (Fikenzer et al., 2020b; Mon-López et al., 2020; Pillay et al., 2020), and these may not be universal amongst all athletes.

This study did not consider the geographical or physical exercise or PA context. However, we hypothesize that players in this study would be unable to gather in training facilities for training, matches, and may have undertaken individual training in their own home and/or backyard because of lockdown. These athletes may have found it difficult to ensure exercise intensity to improve and maintain physical fitness and performance at the required level for handball players because individuals training at home and/or in their backyards may be unable to perform the high-intensity intermittent exercises or handball-specific exercises such as the team training and matches.

**Implications and good practices**

Handball players’ lives have been disrupted by the COVID-19 pandemic. There are major psychological repercussions of athletes’ confinement due to lifestyle modification, as they have no reference to this new situation (Tayech et al., 2020). It is evident that athletes must follow a balanced rhythm of life, appropriate nutritional practices, exercise, and sleeping sufficiently (Tayech et al., 2020; Meyer et al., 2021). Thus, a recommendation that can be made from the results of this study is that it is important for handball players to create a handball-specific exercise program to prevent disability after returning to the sport (Tayech et al., 2020). Training during home confinement will typically be limited to strength, power, and muscle endurance exercises, general physical preparation (e.g., aerobic training on a cycle ergometer), and stretching, amongst other isolation-limited activities. Acute responses to higher intensities and volumes of exercise can
involve a greater risk of illness and impaired immune function (Moreira et al., 2009; Puta et al., 2016). In this context, Tøresdahl and Asif (2019) advised athletes to follow a conservative approach, limiting training sessions to <60 min and to <80% of maximum effort during this time to prevent COVID-19. Herrera-Valenzuela et al. (2020) recommended high-intensity interval training (HIIT) for Olympic sports athletes that can be performed at home, to maintain their physical fitness, and cardiorespiratory endurance, and musculoskeletal health. Improving balance may improve strength, power, and speed (Behm, 1995; Hammami et al., 2016) and enhance subsequent training adaptations (Chaouachi et al., 2014). Balance training prior to power (plyometric) training can improve the degree of plyometric training adaptations (Hammami et al., 2016). Since balance exercises can typically be performed without additional equipment, it may be pragmatic for athletes confined during COVID-19 to emphasize balance training.

**Limitations**

There are several limitations of this research project, which we accept. However, one pertinent strength is the large sample size considered from multiple continents, enabled by our multilingual IPAQ-SF dissemination. We accept this study has the disadvantage of a regional bias in responses to the survey, despite this survey being open for handball players worldwide and consortium colleagues distributed the link to the electronic survey via a range of methods. For example, 85% (1153/1359) of the participants were recruited in Asia. Handball players from Japan (n=758; 56% related to the whole sample and 66% related to the Asia sample) were significantly overrepresented. Likely, nominated local colleagues that distributed the link in Japan were handball experts and they had more access to handball clubs, local federation, and teams. However, we accepted this as our aim was to reach many populations of handball players. The main limitation in this study however, as with all self-reporting, is the possibility of reporting bias
of PA, which is common among the respondents of a self-reported questionnaire. However, we have asked the same questions in the survey about the two different periods (before and during home confinement by COVID-19). Thus, we speculate that the degree of bias is similar based on internal consistency of respondents.

Regarding the gender comparison, we used two groups with significantly different sample sizes (male: n=901 vs. female: n=458). From a statistical point of view, this is disadvantageous for variance analysis. The more unequal the sample sizes, the greater the p-value (greater probability of non-significant results) with constant differences between the groups. Therefore, results may be biased by having unbalanced groups (Bortz and Schuster, 2010). Accordingly, results should be considered with caution, especially due to the sample imbalance with three countries being more prominent in the sample.

**Future Research Lines**

Future study designs could consider more variables in relation to training and recovery conditions (e.g., available space, training machines), and mood (e.g., motivations, private, family situation) of the players. Moreover, an improvement in monitoring systems for training quantity and quality would be desirable in order to draw conclusions that are more objective. For example, wearable technologies may be able to further elucidate the effects of COVID-19 confinement on PA, but this would require requires skills in big-data and web technologies. Finally, conducting a longitudinal study covering the pre-, during- and post-isolation periods through various measurements could provide information on how PA habits compared to before and after lockdown, although this would have required considerable foresight.
To our knowledge, this is the first study concerning handball players during COVID-19 that establishes differences by gender, playing position, and sporting level. The confinement period has influenced the days, hours, and intensity of PA. Furthermore, COVID-19 confinement induced a marked decrease in PA of all intensities. Moreover, sitting time increased, which we believe indicates a more sedentary lifestyle. These observations may be used to inform development of PA recommendations during prolonged home confinement and reduced ability to train in a team handball and/or indoors setting. The aim of this study was to determine PA changes since the COVID-19 outbreak in handball players. We hypothesized that PA would decrease as a result of restrictions, and these data have led us to accept this hypothesis. Conversely, for all PA variables, no effects of competition level (handball league) or gender (male vs. female) were observed. Thus, we reject our secondary hypotheses.
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Table legends

**Table 1.** Description of conditions of lockdown in the different countries of participants* during the first lockdown

**Table 2.** Description of the sample (n=1359) regarding origin and handball activity

**Table 3.** Demographic and anthropometric characteristics of all participants (n=1359).

**Table 4.** Comparison of physical activity parameters depending on gender before and during confinement. Values are given as mean ± SD. Significant effects (main effect criteria: p < 0.05 and η² > 0.10 and d > 0.8) highlighted in bold.
Figure legends

Figure 1a-c. Sitting hours per weekday depending on playing positions (a), gender (b) and level of handball league (c)