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*Original research papers*

# EFFECT OF COVID-19 ON MAINTAINING BALANCE IN HIGHLY SKILLED HANDBALL PLAYERS

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**Abstract**
***Introduction.*** The aim of this study was to evaluate the effect of COVID-19 on maintaining balance in highly skilled handball players during the performance of the modified Romberg test. ***Material and Methods.*** As part of a larger investigation that was initiated in 2019, twelve professional handball players were recruited to participate in a study that was designed to measure static balance performance. Following the initial pre-test, six participants (body height 184.8 ± 4.7 cm; body weight 85.5 ± 3.3 kg; age 21.3 ± 1.2 years) contracted COVID-19. The remaining six participants (body height 188.7 ± 2.6 cm; body weight 92.3 ± 3.7 kg; age 26.3 ± 3.3 years) never tested positive for COVID-19 and pre-sumably were not infected with the virus. The experimental design required all participants to complete an initial balance assessment (pre-test) and a later balance assessment (post-test). To fully analyze our data, we conducted a 2 (condition: COVID, no-COVID) X 2 (test: pre-test, post-test) ANOVA with repeated measures on the second factor. ***Results.*** Our research results showed that the skilled handball players who contracted COVID-19 mani-fested a significant decrease in balance performance from the pre-test which occurred prior to being infected with COVID-19 relative to the post-test which occurred following the COVID-19 infection. ***Conclusions.*** In conclusion, the results we have reported here are the first to show an objectively measured association between COVID-19 and the ability to maintain balance. Further intensive multifaceted research on this issue is needed.

**Key words:** sports, COVID-19, pandemic, athlete, handball players

## Introduction

Due to the COVID-19 pandemic, many opportunities to be physically active were suspended, including school-based physical education, sports training, fitness centers, playgrounds, and walking trails. This was introduced by directives to practice social distancing. This unpredictable situation generated overall concern about the negative health consequences of inactivity and sedentary behavior [1]. People were forced to look for innovative ideas for home workout and advice on lifestyle to keep healthy, safe and fit [2, 3]. Sports club managers and athletes also took up the challenge of introducing the methods of adapting physical training during social isolation, e.g. in handball [4] because any period of physical inactivity can have a significant impact on the physical and mental state of an athlete in high-performance sport. One study showed that sports coaches encountered difficulties related to training programming and IT use with conducting the practice sessions in the virtual environment [5]. The high transmission rate of COVID-19 in pro-fessional athletes also caused important sporting events to be postponed, i.e. UEFA Champions League Final and the Olympic Games 2020 (Tokyo, Japan). When sporting competitions were resumed, the goal was to provide closed competitions with no spectators and journalists present at the venue. It was a very demanding challenge for everyone. Additionally, this situation required that sporting equipment should be frequently disinfected [6]. A number of new measures for protection against COVID-19 transmission started to be introduced, i.e. participants were required to submit health declaration forms, undergo body temperature measurement, use disinfectants, use the changing room at the same time by only several attendees, wear a surgical mask (but not during physical activity), and also not to shake hands with opponents and referees. However, bodily contact is inevitable in sports training and competitions, especially in contact sports, e.g. handball, basketball, football, or wrestling. Undoubtedly, all these additional actions caused confusion in the organization of professional sports training and competition in all individual and team sports. Therefore, practical recommendations were developed for injury prevention and the preparation of training sessions for professional athletes returning to sport after the COVID-19 lockdown [7].

The highest incidence of injuries is seen in team sports such as football, basketball and handball [8, 9, 10]. To prevent injuries, scientists recommend that balance exercises should be incorporated into an athlete's regular training [11]. For example, the results showed that senior men's elite soccer showed a substantial decrease in the rate of injuries to the anterior cruciate ligament as a result of a static balance training program [12]. Balance is determined as the ability to maintain the body's center of gravity within its base of support. The balance can be categorized as either static balance, which is the ability to sustain the body in static equilibrium or within its base of support

[13], and dynamic balance. Dynamic balance is considered to be more challenging because it requires the ability to maintain equilibrium during a transition from a dynamic to a static state. Both types of balance require integration of visual, vestibular, and proprioceptive inputs to control the body within its base of support [14]. There is solid evidence that sports training can improve sensorimotor performance and postural control, e.g. in gymnastics [15], tai chi [16], handball [17] or judo [18]. Balance is essential to the performance of fundamental motor skills like throwing, jumping, hopping and skipping [19]. It is the reason why balance is very important in handball because a handball player is a thrower, sprinter, pivoter and jumper. This is due to the fact that during high-speed motor skill performance, both balance control and high-level visual control are needed [20], which is characteristic of the dynamic conditions of the handball game. Handball players need to maintain balance as they run at high speed, change direction and powerfully throw the ball to pass or shoot [21]. However, during penalty shot performance, static balance is essential, and postural sway needs to be controlled because a handball player must execute this skill with precision to score a point.

There are not many studies measuring balance parameters before and after COVID-19 infection in professional handball players. This study aimed to evaluate the effect of COVID-19 on maintaining balance in highly skilled handball players during the performance of the modified Romberg test. Given the previous research, we hypothesized that athletes who had COVID-19 would have impaired balance compared to balance prior to a COVID-19 infection.

## Material and Methods

### *Participants*

Following the initial pre-test, six participants (body height 184.8 ± 4.7 cm; body weight 85.5 ± 3.3 kg; age 21.3 ± 1.2 years) contracted COVID-19 (group E). They were diagnosed with COVID-19 by a medical practitioner, which was confirmed by RT-PCR assay. The remaining six participants (body height 188.7 ± 2.6 cm; body weight 92.3 ± 3.7 kg; age 26.3 ± 3.3 years) never tested positive for COVID-19 and presumably were not infected with the virus (group C). The experimental design required all participants to complete an initial balance assessment (pre-test) and a later balance assessment (post-test). Between the two assessments, players were not allowed to train. Six participants recovered from the infection in the course of their participation in the present study. Specifically, none of the participants had an active infection of COVID-19 while they participated in our study. All participants were not injured and trained in a high-performance Academic Sports Club, and took part in an average of five training sessions and one competitive match per week.

### *Study design*

This study investigated the effect a COVID-19 infection had on the static balance ability of players of a professional handball team. The study was performed following the ethical standards of the Helsinki Declaration and the participants signed an informed consent form. All participants underwent two balance assessments. One assessment occurred prior to their COVID-19 infection and the second assessment was administered following the infection. The second (i.e., post-COVID) assessment was conducted approximately one month following the completion of their COVID quarantine. It is worth noting that all athletes on the professional handball team had their balance assessed in 2019 per their involvement in a separate research study. As the COVID-19 pandemic spread through the handball team in 2020 and 2021, athletes who were infected with the virus were then recruited to participate in the present study.

All participants performed an individual 3-minute warm-up. The modified Romberg test is an appropriate tool to diagnose sensory ataxia: a gait disturbance caused by abnormal proprioception involving information about the locations of joints [22]. It has been used in clinics for 150 years, however, and its ability to objectively test the relationship between human bipedal locomotion and the vestibular system has been verified several times [22, 23]. It is also proven to be a sensitive and accurate means of measuring the degree of disequilibrium caused by central vertigo, peripheral vertigo, and head trauma [24, 25]. The Romberg test's ability to gauge true proprioception status can be confounded by the vestibular and vision somatosensory system, which may compensate with vestibular function and vision. The Romberg test sign removes the visual and vestibular components that contribute to maintaining balance, and can thus identify specifically a proprioception-related neurologic disease. The Romberg test was used to investigate the effect COVID-19 had on static balance. The Romberg test involves standing with the individual's feet tandem and upper extremities extended so that the arms are parallel to the floor. The participants performed this test for 10 seconds with their eyes open and 10 seconds with their eyes closed. The tests were performed in the same sports uniform the athletes wore during match play.

The measurements were made using a Kistler force plate (Type 2812A1-3). Ground reaction forces were collected with 100 Hz and band pass filtered. Data from the force plate were processed and calculated by BioWare® Software (Kistler). Data from the force platform were processed to obtain postural parameters about the center of pressure (COP) displacements. The following parameters in the anteroposterior (AP) and mediolateral (ML) axes were analyzed: maximum excursion of COP along the axes (RAP and RML), mean velocity of COP displacements along the axes (MVAP and MVML), and work distribution along the axes (WAP and WML).

### *Statistical analysis*

Normality of distribution was checked with the Shapiro-Wilk test (StatSoft, Inc. STATISTICA version 13.0), and normal distribution was found. To fully analyze our data, we conducted a 2 (condition: COVID, no-COVID) X 2 (test: pre-test, post-test) ANOVA with repeated measures on the second factor after Bonferroni adjustments. All differences between conditions were calculated using the Fisher's post hoc NIR test. All the statistical analyses were performed using STATISTICA software (TIBCO Software Inc. (2017).

## Results

All results are presented in Table 1. There were no significant differences between groups during pre-test (FAP – 21%, FMP – 66%, AAP – 46% and AML – 64%).

The ANOVA analysis revealed the main effect of Time for AAP ($F(1.10) = 6.233$, $p = 0.032$, $\eta2 = 0.384$) as well as interaction between Time and Group for FAP ($F(1.10) = 3.001$, $p = 0.05$, $\eta2 = 0.231$), FML ($F(1.10) = 5.161$, $p = 0.046$, $\eta2 = 0.340$) and AAP ($F(1.10) = 6.199$, $p = 0.032$, $\eta2 = 0.383$). Fisher post-hoc analyses revealed significant Time effect in FAP (23%, $p = 0.05$), FML (116%, $p = 0.018$) and AAP (55%, $p = 0,005$) in group 1 only. During the post-test, we noticed that the scores between the two groups were similar (FAP – 9%, FMP – 45%, AAP – 17% and AML).

**Table 1.** Mean values ± SD (in brackets) of COP parameters

| | Group | Pre-test | Post-test |
|---|---|---|---|
| **FAP [N]** | 1 | -4.93 (0.79) | -3.81 (1.28) |
| | 2 | -3.92 (1.47) | -4.15 (1.74) |
| **FML [N]** | 1 | 0.32 (0.56) | -0.69 (1.13) |
| | 2 | -0.53 (1.03) | -0.38 (1.09) |
| **AAP [cm]** | 1 | -1.08 (0.96) | 0.50 (1.49) |
| | 2 | 0.59 (1.47) | 0.59 (1.60) |
| **AML [cm]** | 1 | -3.55 (2.79) | -5.53 (2.58) |
| | 2 | -5.81 (2.36) | -6.12 (2.20) |

## Discussion

COVID-19 affects people differently with its impact ranging from respiratory distress syndrome, pneumonia and other health problems, which can lead to poor prognoses, including death [26]. Despite the fact that athletes do not belong to the risk group for severe course of the COVID-19, many of them have also been affected by COVID-19 infections.

The aim of the current study was to evaluate the effect of COVID-19 on maintaining balance in highly skilled handball players. Our hypothesis was confirmed because the athletes who had COVID-19 had impaired balance compared to balance prior to the COVID-19 infection.

The sport has also been affected by COVID-19 pandemic effects, including the postponement of professional training, tournaments, and massive sports events. It is essential to consider that participation in official handball competitions is quite relevant for clubs and countries. Therefore, coaches and professionals were responsible for maintaining handball players' physical fitness during the forced break. Our research results showed that the skilled handball players who contracted COVID-19 had a significant decrease in balance performance from the pre-test which took place prior to being infected with COVID-19 relative to the post-test which was performed following the COVID-19 infection. In addition, the skilled handball players who were not infected with COVID-19 did not demonstrate the same deterioration in balance performance in the same period. These findings prove that getting infected with COVID-19 has a negative impact on static balance performance in a group of highly skilled handball players. Some scientific evidence showed that COVID-19 infection caused neurological complications [27] such as headaches, impaired consciousness, anosmia, paresthesia, myalgias [28]. The COVID-19 disease can cause dizziness, which may be due to the involvement of vestibular and visual systems, or their central connections [29]. The impact of COVID-19 infections on the audio-vestibular system has been examined as well [30]. Therefore, neurological COVID-19-related symptoms might also affect motor control. Additionally, sensory information is essential to cognitive control of human movement, movement planning, organization, and execution [31], and if the quality and processing of sensory information is impaired, motor performance is also affected (e.g. static balance skill) [32]. Mental health issues are also associated with a decline in motor control. COVID-19 outbreaks caused the increase in psychological symptoms [33], i.e. depression, anxiety, fatigue, insomnia, irritability, and indecisiveness [34]. For example, an investigation reported that one of the most common changes in gait control exhibited by people who have anxiety include dysfunction in balance [35]. Cardiorespiratory complications caused by COVID-19 may also affect balance control because individuals infected with COVID-19 may be more prone to periods of prolonged inactivity, i.e. a reduced number of steps and sitting or lying for long time, which in turn contributes to the reduction in muscle mass, strength, and a decrease in cardiorespiratory fitness [36, 37]. Possibly, these periods of physical inactivity in our study participants who contracted COVID-19 caused a decrease in their static balance skill. However, the interpretation regarding the COVID-19 effect on balance in skilled handball players should be treated cautiously because we need to have more scientific evidence in this vein. To know more about that we advise to include specialists, i.e. psychologists, neurologists, physiotherapists and physiologists for cooperation with athletes who were infected with COVID-19. We recommend that coaches and professionals responsible for physical preparation of skilled athletes should analyse our research results and take into account static balance exercises in their training programs. No complementation in training protocol by static balance exercises may reduce athletic performance, especially in handball, because this skill is essential in this sport [21]. Moreover, improving balance skill may further improve strength, power and speed [38] and enhance subsequent training adaptations [39]. Also, applied balance exercises prior to plyometric training can improve the level of plyometric training adaptations [38]. Additionally, balance exercises are strongly recommended in regular athletic training to prevent injuries [40]. Balance exercises can typically be performed without additional specific equipment.

The main limitation of our study was that only handball players participated in the current research, with no highly skilled athletes of different sports. Further research in this vein is needed to fully understand the lasting impacts COVID-19 has on motor behavior of skilled athletes.

## Conclusions

In conclusion, the results we have reported here are the first to show an objectively measured association between COVID-19 and the ability to maintain balance. Further intensive multifaceted research on this issue is needed. Future research should continue this investigation and compare individuals' balance following COVID-19 infection with individuals who have not had COVID-19. Additionally, it would also be valuable to understand whether these balance issues are temporarily observed or long-lasting. These results show that following self-isolation after a COVID-19 infection, there were decreases in balance performance. Longitudinal studies are needed to understand the impact of COVID-19 on sensorimotor behavior, especially as an effect of kinesthetic senses reduction resulting from the COVID-19 disease.

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