Prevention and Rehabilitation

The impact of anthropometric measures on plantar pressure distribution in male handball players and non-athletes: A cross-sectional study

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\begin{abstract}
\textbf{Background:} Increasing body anthropometry brings substantial spinal stress, which influences the spinal curvatures; this in turn may affect the foot plantar pressure distribution.

\textbf{Objectives:} This study investigated the impact of body anthropometry on static plantar pressure distribution and their relationship among handball players and non-athletes subjects.

\textbf{Methods:} Thirty handball players aged from 21 to 26 years, and thirty age-matched non-athletes subjects aged from 21 to 28 years participated in this study. The spinal lordosis and kyphosis angles, trunk length, pelvic tilting, and pelvic rotation were evaluated using Formetric 4-dimensions and the Pedoscan device was used to assess the plantar pressure distribution.

\textbf{Results:} The handball players were significantly taller, heavier, and have a long trunk length than non-athletes group (\(p < 0.05\)), and a significantly increased thoracic kyphosis, forefeet pressure distribution compared to non-athletes group (\(p < 0.05\)). The handball players had a significantly increased forefoot pressure distribution compared to the rearfeet pressure distribution (\(p < 0.05\)), a high positive correlation between body height, and both trunk length and kyphosis angle (\(r = 0.932, 0.665\) respectively), and the body height showed a high positive correlation with the forefeet pressure distribution (\(r = 0.665\)). There was a high positive correlation between the handball players’ thoracic kyphosis and forefeet pressure distribution (\(r = 0.751\)).

\textbf{Conclusion:} Increasing the handball players’ body height was related to increased thoracic kyphosis and forefoot pressure distribution compared to non-athletes subjects. Additionally, the kyphotic posture of handball players is associated with increasing the total forefoot pressure distribution compared to the total rearfeet pressure distribution.
\end{abstract}

1. Introduction

Sports activities need hard physical exercises, which reduces the adaptation abilities of not only the spinal passive structures but also active structures “muscles that are responsible for the proper shape of the spine” (Lichota et al., 2011; Motow-Czyż et al., 2014). The configuration of spinal anterior-posterior arches in handball, volleyball, and taekwondo athletes tend to be changed. The degree of thoracic kyphosis angle was found to be greater than the degree of lumbar lordosis angle (Lichota et al., 2011).

In many sports, the disproportional body mass and muscle strength, and/or trunk asymmetries are often well-known, due to the uneven stresses applied to the spine and/or sport-specific unilateral muscle work (Barczyk et al., 2005; Hawrylak et al., 2001). The morphological asymmetry in male athletes was defined as the difference between the right and left parts of the body (Krzykała 2012). Athletes with segmental asymmetry might be more susceptible to a range of injuries (Forte et al., 2015).

The spinal anterior-posterior curvatures and the type of body posture may be affected by the training specificity of a particular sport, such as handball (Lichota et al., 2011), characterized by predominant forward flexion posture and a multitude of tackles in both offence and defense, high-intense technical play with strength-related playing movements and high-intensity transitions (Bojsen Michalsik and Aagaard 2015). So, it tends to change the sagittal spinal curvatures and prejudice to spinal injury (Muyor et al., 2013). Since handball is a unilateral loading sport

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Male handball players who are taller than normal have a slightly greater kyphosis angle than players who are shorter (Ameer and Abdel-Azim 2017). Furthermore, the taller the handball players the greater the thoracic kyphosis in comparison to non-athletes subjects (Yildirim and Eroşy 2017), and pelvis and scapula asymmetry in a transverse plane compared to non-training peers (Grabara 2014). In addition, the sports practice showed increased lumbar and thoracic mobility and increased forefoot plantar pressure in the dominant and non-dominant feet during the static condition (Hawrylak et al., 2017).

The plantar foot pressure in disturbed anatomical posture develops physiological disorders in the human body and builds up stress on the musculoskeletal system (Park et al., 2009). The kyphotic posture of the handball players displaces the center of mass anterior (Ameer and Abdel-Azim 2017; Lichota et al., 2011; Muyor et al., 2013), which disturbs the postural control (Roghani et al., 2017), plantar pressure distribution and loading patterns on the foot (Mousavi et al., 2020). Shiotani et al. (2000) reported that kyphotic subjects preserve their anteroposterior equilibrium by increasing the heel contact duration. So, it is recommended to conduct more studies to investigate the plantar pressure of different sports, rather than soccer and basketball players (Esparza et al., 2011).

Body anthropometry appears to have a significant impact on playing ability and the disturbance in the plantar pressure distribution can influence the athletes’ performance (Abdul Razak et al., 2012; Buldt et al., 2018). So, athletic trainers should consider the difference in plantar pressure patterns of athletes while designing an intervention protocol (Yildizer et al., 2008). However, there is little information available regarding the relationship between male handball players’ upper body posture and postural control (body weight distribution and postural sagittal/frontal sway) in relation to body height (Ohlendorf et al., 2020). Few studies have reported the impact of sagittal spinal curvatures and body height on static foot plantar pressure distribution, which were conducted on patients and normal subjects rather than athletic players (Draus et al., 2015; Min Park et al., 2016; Yildirim and Eroşy 2017).

It was concluded that the dynamic plantar force and pressure inequality delivers valuable information for rehabilitation and exercise to avoid body imbalance and injuries in athletes (Ameer et al., 2022; Thompson et al., 2017). So, it is important to understand if asymmetry exists in the spine of handball players and the extent to which it affects the foot plantar pressure distribution to restore their posture and prevent injuries. This study, therefore, aimed to investigate the impact of body anthropometry on static plantar pressure distribution and their relationship in handball players and non-athletes subjects.

2. Methods

2.1. Study design and setting

This cross-sectional study was conducted in the lab of Faculty of Physical Therapy, xxxxx University. It was conducted between November 2021 and January 2022.

2.2. Sample size calculation

The sample size calculation was conducted by using (G*Power 3.1 software). A pilot study was done on eight participants (four handball players and four non-athletes subjects) before starting the actual study in order to estimate the effect size. So, the sample was determined as 52 participants (27 participants/group) according to effect size = 0.81, alpha = 0.05, and power = 0.80.

2.3. Ethical considerations

The research protocol was performed in agreement with the Declaration of Helsinki, and accepted by the ethics committee of Faculty of the Physical Therapy, xxxxx University (P.T.REC.012/002281), and thereafter each participant signed a written consent form.

2.4. Participants

Thirty male handball national players and thirty age-matched non-athletes subjects participated in this study. Their demographic data (age, body height, body weight, BMI, and trunk length) are presented in Table 1. The handball players came from five different local clubs (Heliopolis Sporting Club, The Aviation Club, Maadi Club, Al Zuhour Sporting Club, and Al-Shams club) from Cairo region. Initially, 37 participants were screened for eligibility, seven did not undergo the inclusion criteria which were; 1) attended 120 min training six times per week, 2) their minimum training experience was 3 years, and a maximum of 6 years (5.10 ± 1.13 years). The information related to the training frequency and duration was obtained through a meeting before the evaluation procedures. The inclusion criteria of non-athletes subjects were; University staff members have no sports activities except the normal daily activities and exercises. Of the 34 participants, four participants refused to participate in the study. So, a total of 30 participants in each group completed the study.

The participants were excluded if they had traumatic back injuries, were diagnosed with scoliosis, congenital spine abnormality, a history of neurological disorder or orthopedic surgery involving the back and lower extremities, balance disturbance, or reported any type of foot deformities (pes cavus, pes planus, and excessive pronated or supinated foot).

2.5. Tools used and outcome measures

The DIERS Formetric 4-dimensions (4D, International GmbH, Schlangenbad, model No. 1010112157, Germany) and DIERS Pedoscan (RS scan 1.0 m, International GmbH, Germany) were used for the optical measurement of the spinal sagittal curvatures (lordosis, and kyphosis angles), trunk length, pelvic tilting, pelvic rotation, and plantar pressure distribution. The Formetric 4D system provided four-dimensional images of the spine to detect the trunk length, kyphosis angle, lordosis angle, pelvic tilt, and pelvic rotation. It depends on the photogrammetric record of the spine with a rasterstereography procedure and DiCAM v2.2.0. The Pedoscan system (A 50 cm wide platform containing 4096 pressure sensors, and data gathering frequency was 300 Hz) (Lee et al., 2015) delivered the percentage of plantar pressure distribution in four plantar areas (right forefoot, right rearfoot, left forefoot, and left rearfoot) during standing (Draus et al., 2015; Yildirim and Eroşy 2017).

The measuring data delivered an accurate 3-dimensional model of the spine with a real-time foot pressure map. The feet static images of Pedoscan are provided with a color representation of the feet and metrical information on the front-back and left-right pressure distribution in percentage. The consistency of the measurements achieved with the Formetric 4D spine-shape analysis method has been verified by a

<table>
<thead>
<tr>
<th>Variables</th>
<th>Handball players group (n = 30)</th>
<th>Non-athletes group (n = 30)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>23.54 ± 1.32</td>
<td>24.26 ± 1.74</td>
<td>0.076</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>80.15 ± 6.96</td>
<td>74.11 ± 5.33</td>
<td>0.001*</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>180.20 ± 6.04</td>
<td>171.35 ± 3.74</td>
<td>0.001*</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>24.62 ± 1.20</td>
<td>25.24 ± 1.65</td>
<td>0.105</td>
</tr>
</tbody>
</table>

Data are demonstrated as mean ± standard deviation, *p value < 0.05 means significant difference.
comparison with digital and objective X-ray images. This device has a highly accepted validity compared with X-ray images, with excellent inter-and intra-rater reliability (Tabard-Fougere et al., 2017). The rasterstereography validity, compared with X-ray images, was demonstrated by Mohokum et al. (Mohokum et al., 2015) who showed that rasterstereography assists the spinal column analysis with the least amount of absorbed radiation and aids in detecting numerous spinal deformities, such as the presence of excessive kyphosis. Moreover, the accuracy and reproducibility of Pedoscan were reported by many studies (Draus et al., 2015; Schroder 2009; Song et al., 2015).

2.6. Procedure

The body height and mass were assessed using a DETECTO 339 Physician’s Scale with height rod and weighing scales (Detecto Model #339, Webb City, Missouri, USA). The BMI was calculated as body mass (kg)/height (m$^2$). Each participant stood barefoot on the device platform, and straight with vision parallel to the horizontal line and both arms beside his body. The examiner elevates the rod of the scale to be in contact with the vertex of the skull (McCann et al., 2018).

The stereographic projector/camera was calibrated by placing a flat whiteboard in the place of the participants; the volume origin calibration was performed every day through the whiteboard image. Its height was modified according to the participant’s body height. The cameras and their resultant strobes were adjusted to yield the best photographic resolution and fields of view. Furthermore, the resistive measurement plate of Pedoscan is calibrated from time to time (every 2–3 months) to maintain its sensitivity. The participant was instructed to stand barefoot in a comfortable erect posture on a fixed Pedoscan platform in a dark room. In addition, the participants wore only their underwear (the area from the neck to the two lumbar dimples is free from clothes). His head directed forward with open eyes and without any movement or talking (Draus et al., 2015).

The trial was canceled if the participant changed the original position, talked, or moved any segment of his body (head, arms, feet, and trunk). White light and parallel horizontal lines were seen on the participant’s back; these lines covered the whole length of his back from the neck region to the lumbar region. The data were extracted using mathematical modeling of the device software. The trunk length from C7-VP (VP: vertebral prominence) to the lumbar-DM (DM: the point located on the back surface between the left and right lumbar dimples) was detected using the Formetric device. Moreover, the kyphosis and lordosis angles, pelvic tilt, and pelvic rotation were measured with the reported precision of depth error (z-axis) \(< 0.25\) mm and lateral error (x/y axis) \(< 0.20\) mm (Lippold et al., 2006). The image quality was enhanced by adjusting the contrast and brightness of the camera. The black and white positive images were scanned and cropped to decrease the data size. The 3-dimensional model of the spine was created automatically to quantify the measured anthropometric variables. Verification of the sacrum point, left and right lumbar dimples, vertebra prominence (C7), and other anatomical landmarks were done to ensure their accuracy. The image that is displayed for the 4-dimensional average measurement type is the average of all the photographs that were taken. Thus, there is only one image rather than a video as the outcome (Fig. 1).

To measure the plantar pressure distribution, each participant stood barefoot on the plantar pressure distribution platform (Abdelraouf & Abdel-aziem 2021; Draus et al., 2015), and the snapshot of percentage feet plantar pressure distribution measurement was obtained through the pressure maps; Total forefoot pressure (TFP) and Total rearfoot pressure (TRP) were calculated for both groups. The device mat has pressure sensors that change the mechanical pressure of the body weight into electrical signals, these signals are manipulated by a mathematical model of the device software, which can be extracted through the printouts. The measurement of each participant was collected on the same day under a constant room temperature, which was repeated three times. The average and standard deviation (mean $\pm$ SD) values of the variables of interest were calculated. The total percentage of forefeet and rearfeet plantar pressure distribution was calculated (through the detection of the percentage of four-foot quadrants). The percentage of forefeet plantar pressure distribution included the summation of the percentage of the right and left forefeet, while the percentage of rearfeet

Fig. 1. The percent pressure distribution of feet quadrants with 4-dimensional average of the spine.
included the summation of the percentage of the right and left rearfeet. All these percentages were relative to the body pressure and detected by the Pedoscan device.

2.7. Statistical analysis

IBM Statistical Package for the Social Sciences (SPSS version 20) for Windows software was implemented for the statistical analyses. The normality of the distributions was confirmed by the Shapiro-Wilk test (p > 0.05). The independent t-test was used to identify differences in anthropometric data, percentage foot plantar pressure distribution, spinal sagittal curvatures, and pelvic orientation between both groups; the significance level was set at p < 0.05. Correlation analyses were applied to examine the potential effect of the body height and kyphosis angle on the percentage of total forefoot plantar pressure distribution in both groups by conducting a Pearson correlation test (r) with a significance level set at p < 0.05.

3. Results

Concerning age and BMI, there was no significant difference between the handball players and non-athletes groups (p > 0.05). However, the handball players were significantly taller and heavier, and have a long trunk length than non-athletes subjects (p < 0.05). The handball players showed a significant increase in thoracic kyphosis compared to the non-athletes subjects (p < 0.05). There was no significant difference in the lordosis angle, pelvic tilt, or pelvic rotation between both groups (p > 0.05).

The handball players demonstrated a significant increase in the total forefoot plantar pressure distribution compared to non-athletes subjects (p < 0.05). Although there was a significant increase in the percentage of total forefoot plantar pressure compared to the total rearfeet pressure in handball players (p < 0.05), there was no significant difference between the percentage of total forefoot and total rearfeet pressure of the non-athletes subjects (p > 0.05). Moreover, there were no significant differences in pelvic tilt, and pelvic rotation between both groups (p > 0.05), as shown in Table 2.

Table 2 shows that the handball players have a high positive correlation between body height, both trunk length and kyphosis angle (p < 0.05), and a moderate positive correlation between trunk length and kyphosis angle. While there was a weak positive correlation between body height and lumbar lordosis angle (p< 0.05). Furthermore, the body height showed a high positive correlation with the percentage of total forefoot plantar pressure distribution (p< 0.05). A high positive correlation between the handball players’ kyphosis angle and the total percentage of forefoot plantar pressure distribution was detected (p < 0.05). Meanwhile, there were no correlations between the total percentage of forefoot plantar pressure distribution, on one hand, and pelvic tilt, and pelvic rotation on the other hand (p > 0.05). The body height showed no correlations with pelvic tilt, and pelvic rotation (p > 0.05). A moderate positive correlation was detected between the kyphosis angle and the lumbar lordosis angle (p < 0.05). There was no significant correlation between BMI and trunk length, body height, lumbar lordosis angle, and total percentage of forefoot plantar pressure distribution (p > 0.05).

Concerning the non-athletes subjects, there was a high positive correlation between the body height and both trunk length and kyphosis angle (p < 0.05), and a moderate positive correlation between trunk length and kyphosis angle (p < 0.05). Also, a high positive correlation between the body height and lumbar lordosis angle was detected (p< 0.05). There is a low positive correlation between the body height and the percentage of total forefoot plantar pressure distribution (p > 0.05). Furthermore, the kyphosis angle of the non-athletes subjects showed a low positive correlation with the percentage of total forefoot plantar pressure distribution (p > 0.05). Whereas, there were no correlations between the total percentage of forefoot plantar pressure distribution and each pelvic tilt, and pelvic rotation (p > 0.05). The body height showed no correlation with pelvic tilt (p > 0.05), and a weak positive correlation with pelvic rotation (p < 0.05). A moderate positive correlation was detected between the kyphosis and lumbar lordosis angles (p< 0.05). There was no significant correlation between BMI and trunk length, body height, lumbar lordosis angle, and the total percentage of forefoot plantar pressure distribution (p > 0.05), as shown in Table 3.

4. Discussion

The results of this study showed that the selected variables differentiated the handball player group from the non-athletes group. Even though significant differences in the body pressure, height, trunk length, and kyphosis angle were detected. There were no significant differences in the BMI, lordosis angle, pelvic title and pelvic rotation. These results are consistent with the previous studies; the study of Grabara (2015) reported a postural difference with increasing thoracic kyphosis in volleyball players more than the non-trained individuals and the specificity of activities achieved through the training performed in a specific sport may affect the contour of the anterior-posterior curving of the spine, and consequently may change the body posture (Lichota et al., 2011).

Furthermore, Ameer & Abdel-aziem (2017) concluded that with increasing the body height of handball players, the body weight and the trunk length tend to increase, and that tall handball players suffer from excessive thoracic kyphosis more than their short counterparts, without any significant variations in the lumbar lordosis angle. Several studies found a relationship between various sports activities and the shape of the sagittal spinal curvatures (López-Minarro et al., 2010; Rodríguez-García et al., 2008; Wood 2002); Lichota et al. (2011) found that volleyball and handball players revealed more thoracic kyphosis angle than lordosis angle, and Rajabi et al. (2008) proposed that sports needing forward flexed postures are accompanied by an excessive thoracic kyphosis angle during normal standing.

The present results revealed significant differences in the percentage foot pressure distribution between both groups, which might be accounted for by the significant differences in body height and weight. This result is in line with the outcomes of Walsh et al. (2017) who proved the effect of increasing body weight on increasing plantar pressure.

Table 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Handball players group (n = 30)</th>
<th>Non-athletes group (n = 30)</th>
<th>p-value</th>
<th>95% CI for Difference</th>
<th>Effect size (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk length (cm)</td>
<td>46.82 ± 0.75</td>
<td>46.33 ± 0.84</td>
<td>0.020*</td>
<td>0.080</td>
<td>0.096</td>
</tr>
<tr>
<td>Kyphosis angle (°)</td>
<td>45.42 ± 3.42</td>
<td>41.94 ± 4.66</td>
<td>0.002*</td>
<td>1.303</td>
<td>5.650</td>
</tr>
<tr>
<td>Lordosis angle (°)</td>
<td>28.94 ± 4.98</td>
<td>28.22 ± 3.51</td>
<td>0.522</td>
<td>-1.511</td>
<td>2.945</td>
</tr>
<tr>
<td>PFPPD (%)</td>
<td>58.25 ± 1.98</td>
<td>49.65 ± 1.58</td>
<td>0.001*</td>
<td>7.672</td>
<td>9.522</td>
</tr>
<tr>
<td>PRPPD (%)</td>
<td>41.74 ± 1.95</td>
<td>50.35 ± 1.58</td>
<td>0.722</td>
<td>-1.534</td>
<td>2.201</td>
</tr>
<tr>
<td>Pelvic tilt (°)</td>
<td>4.30 ± 2.51</td>
<td>4.00 ± 4.40</td>
<td>0.164</td>
<td>-0.392</td>
<td>2.259</td>
</tr>
<tr>
<td>Pelvic rotation (°)</td>
<td>1.20 ± 2.5</td>
<td>0.31 ± 2.62</td>
<td>0.615</td>
<td>0.615</td>
<td>0.615</td>
</tr>
</tbody>
</table>

Data are demonstrated as mean ± standard deviation, PFPPD; percentage of forefoot plantar pressure distribution, PRPPD; percentage of rearfoot plantar pressure distribution, CI; confidence interval, *p value < 0.05 means significant.
Moreover, several other studies confirmed that weight loss has a great impact on the reduction of plantar pressure (Tabard-Fougère et al., 2017; Wearing et al., 2009).

The current study showed that the total forefoot pressure distribution of handball players was significantly higher and the total rearfoot pressure distribution was significantly lower than the non-athletes group. The long supporting duration on the heel of the handball player did not concur with the findings of Shiotani et al. (2000) who reported that subjects with kyphosis preserve their anteroposterior equilibrium by increasing the heel contact duration. This contradiction was attributed to the measurement condition, they assessed their participants during the walking dynamic condition. In contrast, the present study evaluated the foot plantar pressure distribution during the standing posture. Moreover, their participants were non-athletes.

Although there was a strong correlation established between foot pressure distribution and trunk imbalance, trunk rotation, and pelvic tilt (Teasdale and Simmonse, 2001). The current study showed no statistically significant difference in pelvic tilt and pelvic rotation between both groups which indicated the neutral effect of pelvic position on foot position and plantar pressure distribution in the selected sample, due to the non-significant difference in lumbar angle between both groups that may affect the position of the pelvis.

Furthermore, the present finding detected strong positive correlations between the body height, trunk length, and thoracic kyphosis in both groups, which is similar to the findings of Fredricks et al. (2005) who reported that the trunk length is one of the components forming the human stature and that there is a positive relationship between body height and sitting height. Likewise, Ameer and Abdel-Azim (2017) reported a strong positive relationship between body height and kyphosis angle; in which increasing body height is associated with increasing kyphosis angle, which was attributed to the gravity effect. Additionally, the increase in body height together with the presence of excessive thoracic kyphosis induces a change in plantar pressure distribution. The sagittal spinal posture might affect the body balance and its relation with plantar pressure distribution should not be neglected. It is significant to detect this degree of postural asymmetry related to different sports or different diseases and its relationship with plantar pressure distribution should not be neglected. It is significant to detect this degree of postural asymmetry and its relationship to plantar pressure distribution through biomechanical analysis. Such findings can help to avoid injuries and improve the subject’s efficiency in various sports. It is also suggested to create individual compensatory and stretching training, especially for the axial muscles that are neighboring the anterior and posterior aspects of the body to adjust the body mechanics and avoid the overpressure areas of the feet.

The study has a clear limitation; it included male subjects only. Therefore, the generalization of the study results is restricted to the male population. Furthermore, this study was applied to handball players only, so future studies should select different players from different populations.

Table 3
Correlations among body height, trunk length, spinal curvatures, and the percentage of forefoot plantar pressure distribution.

<table>
<thead>
<tr>
<th></th>
<th>Handball players group (n = 30)</th>
<th>Non-athletes group (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trunk length (cm)</td>
<td>Body height (cm)</td>
</tr>
<tr>
<td>Body height (cm)</td>
<td>r 0.932* p 0.001</td>
<td>– 0.376* p 0.040</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>r –0.024 p 0.899</td>
<td>0.799 p 0.001</td>
</tr>
<tr>
<td>Kyphosis angle (°)</td>
<td>r 0.522 p 0.003</td>
<td>0.519* p 0.001</td>
</tr>
<tr>
<td>Pelvic tilt (°)</td>
<td>r –0.014 p 0.940</td>
<td>0.500 p 0.146</td>
</tr>
<tr>
<td>Pelvic rotation (°)</td>
<td>r 0.274 p 0.144</td>
<td>0.219 p 0.468</td>
</tr>
</tbody>
</table>

PFPPD: percentage of forefoot plantar pressure distribution, *p value < 0.05 means significant difference.
In conclusion, increasing the body height of the handball players was related to the increase of thoracic kyphosis and forefoot plantar pressure distribution compared to non-athletes subjects. Moreover, the presence of kyphosis with increasing body height tends to increase the forefoot plantar pressure distribution compared to the rearfoot, which increases the plantar pressure distribution on the anterior aspect of the feet. Due to asymmetric spine loads and uneven foot pressure distribution during training, handball coaches should take into account frequent posture and lower extremity assessment among players and include exercise that helps maintain upper body posture and weight distribution in training sessions.

CRediT authorship contribution statement

Mariam A. Ameer: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. Amr A. Abdel-aziem: Conceptualization, Formal analysis, Investigation, Software, Supervision, Writing – original draft, Writing – review & editing. Amany E. Abd-Eltawab: Data curation, Methodology, Software, Writing – original draft.

Declaration of competing interest

There is no conflict of interest to be declared.

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