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Anthropometric and Range of Motion Evaluation of the Lower Limbs' Joints as Factors for Symmetry Assessment at High Level Handball Players Prior to Their Return to Play After An Injury in Lower Limbs.

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Abstract

Asymmetry between the two limbs, either in strength or flexibility, increases the risk of re-injury. The aim of this study was to evaluate the symmetry through anthropometric assesment and to examine the range of motion of lower limbs' joints in handball players upon their return to play after injury. The sample consisted of 15 high level handball players, who had injured their lower limbs and were ready to return to the same competitive activity. These players underwent anthropometric assessment as well as five goniometric assessments of the lower limbs. The results showed asymmetry exclusively in the thigh circumference at a percentage of 26.6%, with the normative limit of one centimeter, and 13.3% with the normative limit of two centimeters. Regarding hip flexion ROM assessment with bent knee and also with stretched knee, as well as in the knee flexion assessment, a percentage 26.8% showed asymmetry. In the measurement of the dorsal and plantar flexion of the ankle joint, a percentage 60% and 33.4% respectively, again showed asymmetry. In conclusion, from the anthropometric assessment and the ROM measurements, a significant percentage of these players did not meet the specific criteria for a safe return to the same competitive activity.

Keywords: symmetry assessment, anthropometric measurement, range of motion, handball players.

1. Introduction

The issue of muscular asymmetries in the lower limbs has been the topic of many researches that emphasize their negative role in sports. Moreover, muscle asymmetries are reported as a risk factor for injury in athletes (Bell, Sanfilippo, Binkley &Heiderscheit, 2014; Bishop, Turner & Read, 2018; Hofmann, Ratamess, Klatt, Faigenbaum& Kang, 2007). In order to achieve a successful rehabilitation of the lower limbs and also a safe return to the same competitive activity, the symmetry between the two limbs must be evaluated (Di Stasi, Myer & Hewett, 2013).

The main causes of injuries are asymmetries in muscle strength, proprioception, joint stability, as well as anatomical and anthropometric asymmetries (Fousekis, Tsepis & Vagenas, 2010). A complete evaluation of the asymmetries between the two limbs would be very useful before returning to the training process and would significantly reduce the chance of injury (Santos et al., 2014). Asymmetry between the two limbs, either in strength or flexibility, increases the risk of re-injury (Di Stasi, et al., 2013; Paterno et al., 2010). Measuring the circumference of the lower limbs muscle groups is one way to get information about their condition. In this way we can evaluate peripheral changes in the body (Clark, Lucett & Kirkendall, 2010). Asymmetry in lean muscle mass between the two limbs in both the quadriceps femoris and gastrocnemius, affects the symmetry of strength and power in jumping.

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Thus, this asymmetry has a partial effect on occurrence of imbalances in strength and power of the lower limbs (Bell et al., 2014).

Moreover, the same researchers report that, although asymmetry in muscle mass does not completely explain functional asymmetry, a greater understanding of this relationship may lead to a further deepening of how asymmetry in the lower limbs affects the occurrence of injuries and how to prevent them. Some authors define as an acceptable normative limit of difference of the thigh regions between the two limbs less than or equal to one centimeter (Zaffagnini, et al., 2006) and other less or equal to two centimeters (Fibiger, 2014).

Measuring the range of motion of the joints is an important component of a complete and integrated anthropometric evaluation process (Clark & Lucett, 2010). It is known that musculoskeletal injuries in the lower limbs are related to the reduced flexibility of the joints, but also to the possible difference in flexibility between the two limbs (Engebretsen, Benum, Fasting, Mølster & Strand, 1990). If an athlete has less than normal range of motion in the dorsiflexion of the ankle, then there is a greater risk of injury at the knee, hip and lumbar spine, compared to other athletes with a normal range of motion (Powers, 2003).

In addition, dynamic knee stabilization can be altered by limited range of motion and limited movement in general (McKeon et al., 2008). Although there is a high rate of recurrence of ankle sprains, there is relatively little research made on the limited range of motion of this joint (Denegar, Hertel, & Fonseca, 2002). Also, the same authors state that, there is a need for better understanding of the limited movement of a joint after an injury.

The muscles that affect the dorsiflexion of the ankle play an important role in the process of absorbing the forces that develop during landing after a jump (Fong, Blackburn, Norcross, Mc Grath & Padua, 2011). In addition, the same authors found that a smaller range of motion in the dorsal flexion of the foot, leads to the development of greater forces and torques during landing. Finally, the researchers report that the limited range of motion in the dorsal flexion of the ankle joint, leads to a greater strain on the anterior cruciate ligaments and therefore a greater risk of possible injury. Some authors report as factors of hamstrings injury, limited flexibility in the hamstrings, reduced flexibility in the hip flexors, decreased flexibility in the quadriceps, but also inadequate flexion of the knee (Freckleton & Pizzari, 2013). Also, some other report that limited flexibility in the hamstrings is a factor of re-injury and additionally stating that a normal range of motion should be one of the essential elements for a safe return to the same competitive activity after an injury in the hamstrings (Magalhães et al., 2015).

The aim of the present study was to evaluate the symmetry through anthropometric assessments (thigh and gastrocnemius muscle) and the range of motion of the lower limbs' joints in high-level handball players prior their return to play after injury.

2. Material and Method

2.1 Participants

The research sample consisted of 15 handball players, nine men and six women. All of them were high level players and competed in teams of the two highest leagues of Greece (Handball Premier for men and A1 for women). The average age of the participants was 22 ± 3.13 years. All those who consisted the sample of the research, before their injury had an active participation in trainings and in games of their teams. Everyone in this study had a lower limb injury. The specific injury led the participants to abstain for at least seven days from the activities of the team (training - games). All participants, before participating in the research process and in particular in the assessments, had the consent of either the doctors, the physiotherapists or their coaches to return to competitive activity. Also, all players gave their written consent regarding participation in the study after being informed of all risks, discomforts and benefits associated with the procedures followed the present study. Procedures were in accordance with the ethical standards of the Committee on Human Experimentation of the Institution at which the research was conducted and with the Helsinki Declaration of 1975.

2.2 Procedures and Instruments Description

For the purposes of the present study, anthropometric evaluations and range of motion measurements were performed in the laboratory. The instruments used in the laboratory were the following: a) for the anthropometric measurements a two-meter measuring tape was used. b) range of motion measurements were made using a Myrin goniometer.

2.3 Measurements

2.3.1 Assessments' description

2.3.1.1Anthropometric assessment

2.3.1.1.1 Measurement of thigh circumference: The subject was in an upright position and in balance. The tape measure was placed at the point of the thigh where the quadriceps showed larger volume (about 20 cm above the patella). The measuring tape had to be stretched and horizontal, but without putting pressure on the thighs of the participants. Two measurements were made at each limb and if the same value was displayed in these two measurements, then this value was eventually recorded. If, on the other hand, any deviation in the values appeared, a third measurement was made and any value displayed in two of the three measurements was recorded. The same procedure was followed at the other limb.

2.3.1.1.2 Measurement of gastrocnemius circumference: The same procedure was followed in this measurement also. The measuring tape was placed at the point of the gastrocnemius where the limb showed the largest volume between the ankle and the knee. The measuring tape had to be stretched and horizontal but without putting pressure on the gastrocnemius of the participants. Two measurements were made at each limb and if the same value appeared in these two measurements, then this value was finally recorded. If any difference in the values appeared, a third measurement was made and any value displayed in two of the three measurements was recorded. The same procedure was followed at the other limb.

2.3.1.2 ROM measurements of lower limbs

2.3.1.2.1 Hip flexion ROM measurement with bent knee: In this measurement, the length of the muscles that extend the hip was estimated. The participant was lying in a supine position in the examination bed. The goniometer was placed on a strap five centimeters above the patella and on the outside of the limb on the lateral line of the femur. Once the goniometer was stabilized, the gravity indicator had to be swinging downwards freely. The goniometer was then reset by moving the gravity indicator so that it coincided with its zero reading. The participant then performed a flexion of the thigh towards the chest, and the examiner then performed a passive flexion of the bent limb to the point of maximum resistance. When it reached the final position of the joint, the degrees displayed on the goniometer were recorded. Two measurements were made at each limb and if the same value was displayed in these two measurements, then this value was finally recorded. In case of any deviation in the values, a third measurement was made and any value displayed in two of the three measurements, was recorded. The same process was repeated at the other limb.

2.3.1.2.2 Hip flexion ROM measurement with a stretched knee: This measurement assessed the length of the hamstrings. The participant was lying in a supine position in the examination bed. The goniometer was placed on a strap five centimeters above the patella and placed on the outside of the limb on the lateral line of the femur. Once the goniometer was stabilized, the gravity indicator had to be swinging downwards freely. The goniometer was then reset by moving the gravity indicator so that it coincided with its zero reading. The examiner then raised the stretched limb of the participant, taking care to avoid lordosis in the lumbar spine, to the point of maximum resistance, and the degrees displayed on the goniometer were recorded. Two measurements were made at each limb and if the same value was displayed in these two measurements, then this value was finally recorded. In case of any deviation in the values, a third measurement was made and any value displayed in two of the three measurements was recorded. The same process was repeated at the other limb.

2.3.1.2.3 Knee flexion ROM measurement: This measurement assessed the length of the anterior femoral muscles. The subject was lying in a prone position in the examination bed with his knees outstretched. The goniometer was placed on the tibia and at a distance of five centimeters above the lateral malleolus, in the line defined by the tubers of the knee joint and the lateral malleolus. Once the goniometer was stabilized, the gravity indicator had to be swinging downwards freely. The goniometer was then reset by moving the gravity indicator so that it coincided with its zero reading. The limb was then passively bent from the examiner to the point where the quadriceps exerted the greatest resistance. The goniometer reading was recorded at the final position of the joint. Two measurements were made at each limb and if the same value was displayed in these two measurements, then this value was finally recorded. In case of any deviation in the values, a third measurement was made and any value displayed in two of the three measurements was recorded. The same process was repeated at the other limb.

2.3.1.2.4 Dorsiflexion ROM measurement of the ankle joint: In this measurement, the length of the posterior muscles of the tibia was estimated. The participant was lying in a supine position with his elbows resting, having his ankle out of the examination bed. The goniometer was placed at the metatarsus, under the phalanges of the toes. Once the goniometer was stabilized, the gravity indicator had to be swinging down freely. The goniometer was then reset by moving the gravity indicator so that it coincided with its zero reading. The examiner pressed the knee slightly so as not to lift and the participant was asked to perform a maximum dorsiflexion of the ankle. Two measurements were made at each limb and if the same value was displayed in these two measurements, then this value was finally recorded. In case of any deviation in the values, a third measurement was made and any value displayed in two of the three measurements was recorded. The same process was repeated at the other limb.

2.3.1.2.5 Plantar flexion ROM measurement of the ankle joint: In this measurement, the length of the anterior tibial muscles was estimated. The subject was lying in supine position with support at the elbows, having the ankle joint out of the examination bed. The goniometer was placed at the metatarsus, under the phalanges of the toes. Once the goniometer was stabilized, the gravity indicator had to be swinging down freely. The goniometer was then reset by moving the gravity indicator so that it coincided with its zero reading. The examiner pressed the knee slightly so as not to lift and the examinee was asked to perform a maximum plantar flexion of the ankle. The goniometer reading was recorded at the final position of the joint. Two measurements were made at each limb and if the same value was displayed in these two measurements, then this value was finally recorded. In case of any deviation in the values, a third measurement was made and any value displayed in two of the three measurements was recorded. The same process was repeated at the other limb.

2.4 Statistical Analysis

Descriptive and inferential statistics were used for the statistical analysis of the results. More specifically, the frequency of values and their corresponding percentage were used, as well as the mean value and the standard deviation (S.D.). In addition, due to the abnormal distribution of the sample, the non-parametric Mann-Whitney U test was used to find statistically significant differences between injured and uninjured limbs in the tests that took place. The significance level was set at 0.05 and the statistical processing of the study data was done using the SPSS 25 program.

3. Results

3.1 Anthropometric Assessment

3.1.1 Thigh circumference: The mean value of the thigh circumference of the injured limbs was 59.1 ± 4.2 cm and that of the uninjured 59.6 ± 4.1 cm. Regarding the symmetry in the circumference of the thighs, between the two limbs, in four cases we had a difference greater than or equal to two centimeters. Therefore, according to the acceptable limit of one centimeter we had 26.6% asymmetry, while according to the normative limit of two centimeters we had a percentage of asymmetry of 13.3% (two cases). Analysis of the data with the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between injured and uninjured limbs $p = 0.74$.

3.1.2 Gastrocnemius circumference: The mean value of the gastrocnemius circumference of the injured limbs was 38 ± 2.2 cm and of the uninjured was 38.1 ± 2.2 cm. As for the symmetry evaluation, no asymmetry appeared in the circumference of the gastrocnemius, between the two limbs of the sample. Analysis of the data with the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between injured and uninjured limbs $p = 0.83$. In addition, Table 1 shows the overall results of the symmetry between the injured and uninjured limbs in the participants, in terms of the thigh and gastrocnemius circumference.

Table 1. Overall results of the limbs' symmetry of Thigh and Gastrocnemius circumference.

Circumference Symmetry of thigh and gastrocnemius		
Participants	Thigh	Gastrocnemius
1	+	+
2	+	+
3	-	+
4	+	+
5	-	+
6	+	+
7	+	+
8	-	+
9	+	+
10	-	+
11	+	+
12	+	+
13	+	+
14	+	+
15	+	+

The + symbol in the table indicates symmetry between the two limbs (difference <1 cm)
The - symbol in the table indicates asymmetry between the two limbs (difference ≥ 1 cm)

3.2 ROM assessment

3.2.1 Hip flexion ROM measurement with knee in flexion: The meanvalue of the hip flexion with the knee in flexion at the injured limbs was $112.4 \pm 7.8°$, while at the uninjured was $113.7 \pm 7.8°$. Given that the normal ROM in the flexion of the hip with a knee in flexion is approximately 120°, we had 12 cases of injured limbs (80%) with a range of motion below the normal limit and 10 cases of uninjured limbs (66.7%) with a range of motion below the normal limit and also two (2) cases (13.4%) of uninjured limbs with values above the normal limit. Regarding the symmetry between the two limbs of the players who were examined, it was found that in four (4) cases we had asymmetry. In two (2) cases (13.4%) the injured limb showed a value below the normal range of motion, while the uninjured limb had a normal range of motion. In the other two (2) cases (13.4%) the injured limb had normal range of motion, while the uninjured limb did not have normal range of motion. In total we had 26.8% asymmetry. Analysis of the data with the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between injured and uninjured limbs $p = 0.65$.

Table 2 shows the overall results of the injured and uninjured limbs of the sample, in terms of values within and outside the normal range of motion, as well as the symmetry between the two limbs.

Table 2. Overall results of normal ROM of the two limbs and their symmetry at the hip flexion with knee in flexion.

Normal ROM and limbs' symmetry			
Participants	Injured Limb	Uninjured limb	Limbs'Symmetry
1	-	-	+
2	+	-	-
3	-	-	+
4	-	-	+
5	-	-	+
6	+	+	+
7	-	-	+
8	-	-	+
9	+	-	-
10	-	+	-
11	-	+	-
12	-	-	+
13	-	-	+
14	-	-	+
15	-	-	+

The + symbol in the table indicates normal ROM and symmetry between the two limbs
The - symbol in the table indicates abnormal ROM and asymmetry between the two limbs

3.2.2 Hip flexion ROMmeasurement with extended knee: The mean of the hip flexion ROM with extended knee at the injured limbs was 81.3° ± 5.7°, while at the uninjured was 84° ± 4.4°. Given that the normal ROM during the flexion of the hip with an extended knee, ranges between 80° - 85°, we had four (4) cases of injured limbs (26.7%), with a range of motion below the normal ROM and one (1) case of uninjured limb (6,7%) with a range of motion below the normal, as well as four (4) limbs, one (1) injured (6.7%) and three (3) uninjured (20%) above the normal ROM. Regarding the symmetry between the two limbs of the participants in the range of motion, it was found that in four (4) cases we had asymmetry. In three (3) cases (20%) the injured limb had a value below the normal range of motion, while the uninjured limb had a normal range of motion. In one (1) measurement (6.7%) the injured limb had a value with normal range of motion, while the uninjured limb had an abnormal range of motion. In total we had 26.7% asymmetry. Analysis of the data with the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between the injured and uninjured limbs $p = 0.174$.

Table 3 shows the overall results of the injured and uninjured limb of the sample, in terms of values within and outside of the normal range of motion, as well as the symmetry of the two limbs.

Table 3. Overall results of normal ROM of the two limbs and their symmetry at the hip flexion with extended knee.

Normal ROM and limbs' symmetry			
Participants	Injured limb	Uninjured limb	Limbs' symmetry
1	+	+	+
2	+	+	+
3	+	+	+
4	+	+	+
5	+	+	+
6	-	+	-
7	+	+	-
8	+	-	-
9	+	-	+
10	-	+	-
11	-	-	+
12	-	-	+
13	+	+	+
14	+	+	+
15	+	+	+

The + symbol in the table indicates normal ROM and symmetry between the two limbs
The - symbol in the table indicates abnormal ROM and asymmetry between the two limbs

3.2.3 Knee flexion ROM measurement: The mean of the knee flexion in the injured limbs was 131.9° ± 10.7°, while in the uninjured it was 132.4° ± 11°. Given that the normal flexibility in the knee flexion ranges from 140°-145°, we had ten (10) cases of injured limbs (66.7%) with a range of motion below the normal limit and ten (10) cases (66.7%) of uninjured limbs with a range of motion below the normal. Regarding the symmetry between the two limbs of the participants, it was found that in four (4) cases we had asymmetry. In two (2) cases (13.4%) the injured limb showed a value below the normal range of motion, while the uninjured limb had a normal range of motion. In two (2) more cases (13.4%) the injured limb showed a value with normal range of motion, while the uninjured limb had an abnormal range of motion. In total we had 26.7% asymmetry. Analysis of the data by the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between the injured and non-injured limbs $p = 0.870$.

Table 4 shows the overall results of the injured and uninjured limb of the sample, in terms of values within and outside the normal range of motion, as well as the symmetry of the two limbs.

Table4. Overall results of normal ROM of the two limbs and their symmetry at the knee flexion.

Normal ROM and limbs' symmetry			
Participants	Injured limb	Uninjured limb	Limbs 'Symmetry
1	-	-	+
2	-	-	+
3	-	-	+
4	-	-	+
5	-	-	+
6	-	-	+
7	+	-	-
8	+	+	+
9	-	-	+
10	-	+	-
11	-	+	-
12	+	+	+
13	+	+	+
14	+	-	-
15	-	-	+

The + symbol in the table indicates normal ROM and symmetry between the two limbs
The - symbol in the table indicates abnormal ROM and asymmetry between the two limbs

3.2.4 Dorsiflexion ROM of the ankle joint: The mean value of the dorsiflexion of the ankle joint at the injured limbs was 19.3°± 5°, while at the uninjured limbs was 20.9° ± 4.8°. Given that the normal flexibility in the dorsiflexion of the ankle ranges from 20° to 30°, five cases (33.4%) of injured limbs and six cases (40%) of uninjured limbs were found with a range of motion below the normal range. Regarding the symmetry between the two limbs of the participants, it was found that in nine (9) cases, we had asymmetry. In four (4) cases (26.7%) the injured limb showed a value below the normal range of motion, while the uninjured limb had a normal range of motion. In addition, in five (5) cases (33.4%) the injured limb showed value within normal range of motion, while the uninjured limb had abnormal range of motion. In total we had 60% asymmetry. Analysis of the data by the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between injured and uninjured limbs p = 0.935.

Table 5 shows the overall results of the injured and uninjured limb of the sample, in terms of values within and outside the normal range of motion, as well as the symmetry of the two limbs.

Table5. Overall results of normal ROM of the two limbs and their symmetry at the ankle dorsiflexion.

Normal ROM and limbs' symmetry			
Participants	Injured Limb	Uninjured Limb	Limbs Symmetry
1	+	-	-
2	+	-	-
3	+	+	+
4	+	+	+
5	+	-	-
6	+	+	+
7	+	-	-
8	-	+	-
9	+	+	+
10	+	-	-
11	-	-	+
12	-	+	-
13	-	+	-
14	+	+	+
15	-	+	-

The + symbol in the table indicates normal ROM and symmetry between the two limbs
The - symbol in the table indicates abnormal ROM and asymmetry between the two limbs

3.2.5 Plantar flexion ROM of the ankle joint: The meanvalue of the plantar flexion of the ankle joint at the injured limbs was 30.9° ± 11.6°, while at the uninjured limbs was 35.6° ± 10.1°. Given that the normal flexibility in the plantar flexion of the ankle ranges from 45° - 50°, 13 cases (86.7%) of injured limbs and 12 cases (80%) of uninjured limbs appeared with a range of motion below the normal range. Regarding the symmetry between the two limbs of the participants, it was found that in five (5) cases, we had asymmetry. In four (4) cases (26.7%) the injured limb had a value below the normal range of motion, while the uninjured limb had a normal range of motion and in one (1) case (6.7%) the injured limb had a value within normal range of motion, while the uninjured limb had an abnormal range of motion. In total we had 33.4% asymmetry. Analysis of the data with the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between the injured and uninjured limbs $p = 0.345$.

Table 6 shows the overall results of the injured and uninjured member of the sample, in terms of values within and outside the normal range of motion, as well as the symmetry of the two limbs.

Table6. Overall results of normal ROM of the two limbs and their symmetry at the ankle plantarflexion.

Normal ROM and limbs' symmetry			
Participants	Injured Limb	Uninjured Limb	Limbs 'Symmetry
1	-	-	+
2	-	+	-
3	+	+	+
4	-	+	-
5	+	-	-
6	-	-	+
7	+	+	+
8	-	+	-
9	-	-	+
10	-	-	+
11	-	-	+
12	-	+	-
13	-	-	+
14	-	-	+
15	-	-	+

The + symbol in the table indicates normal ROM and symmetry between the two limbs
The - symbol in the table indicates abnormal ROM and asymmetry between the two limbs

4. Discussion

Regarding the anthropometrical assessment of the 15 participants, in the context of the present study, no major differences were found between the two limbs, in terms of mean values and standard deviation (at the thigh the difference was 0.5 ± 0.1 and at the gastrocnemius 0.1 ± 0). Zaffagnini et al. (2006), report as an acceptable limit of difference of the thigh circumference between the two limbs less than or equal to one centimeter.

Moreover, Fibiger (2014), reports as an acceptable limit of difference of the thigh circumference between the two limbs less than or equal to two centimeters. From the above it seems that in the circumference of the thigh, according to the limit of one-centimeter, asymmetry appeared in a total of 26.6%, while with the limit of two centimeters we had an asymmetry of 13.3%. Furthermore, no asymmetry was observed in the measurements of the gastrocnemius circumference. The non-parametric Man-Whitney U test showed that there was no statistically significant difference between healthy and injured limbs. In general, the results showed that for the thigh and gastrocnemius, a small percentage showed asymmetry and consequently, if this was taken as a criterion, most players appeared ready to return to the same competitive activity.

The importance of regaining full range of motion is emphasized by Malliou, Gioftsidou, Pafis and Koutras (2015), where it is stated that in order to be performed rehabilitation exercises, full range of motion must have been recovered. At the ROM measurements, performed in the context of the present study and specifically in the measurement of hip flexion with knee in flexion, 80% of the injured limbs did not show full range of motion. The full range of motion, at the hip flexion with knee in flexion, is 120°. However, 10 cases below the normal limit (66.7%) also appeared at the uninjured limbs. This is probably due to the lack or very little use of the appropriate exercise for stretching the specific muscles.

However, when a joint does not have a normal range of motion, then it does not function properly and has reduced efficiency in various activities (Malliou et al., 2015). Regarding the symmetry, in four cases (26.8%) asymmetry was found, with two cases of the uninjured limb showing greater shortening compared to the injured one. The non-parametric Man-Whitney U test showed that there was no statistically significant difference between uninjured and injured limbs.

In contrast, in hip flexion with an extended knee we had only four cases (26.7%) of injured limbs below the normal ROM and one case (6.7%) of an uninjured limb also below the normal ROM. The full range of motion, at the hip flexion with the knee in extension, ranges from 80° - 85°. One possible explanation for this result is that the hamstrings stretch more proactively, due to the high frequency of their injuries. Magalhães et al. (2015), argue that limited flexibility in the hamstrings is a factor of re-injury. The non-parametric Man-Whitney U test showed that there was no statistically significant difference between uninjured and injured limbs. Regarding the symmetry, in four cases (26.8%) asymmetry was found, where in one, the uninjured limb showed greater shortening than the injured one.

At the assessment of the knee flexion, where the full range of motion ranges from 140°-145°, in 10 cases (66.7%) at the injured limbs, we had values below the normal ROM and also, in 10 cases in the uninjured limbs were found values also below the normal ROM. Regarding the symmetry in four cases (26.8%) was found asymmetry, while in two of them theuninjured limb showed greater shortening compared to the injured one. The non-parametric Man-Whitney U test showed that there was no statistically significant difference between uninjured and injured limbs.

Regarding the assessment of the dorsiflexion of the ankle, in five cases (33.4%) we had values below the normal range of motion of the joint at the injured limbs and six cases (40%) with values also below the normal range of motion in the uninjured limbs. The full range of motion in this joint is 20° - 30°. We, in addition, had nine cases (60%) of asymmetry between the two limbs. The mean value at the injured limbs was 19.3° ± 5°, while in the uninjured limbs it was 20.9 ± 4.8. These results are slightly different from the research of Möller, Öberg and Gillquist (1985), who in a sample of 23 football players found an average of 23° ± 1°. Still, in another study by Denegar et al. (2002), 12 basketball players with a history of ankle injury were measured and it was found that the mean in their injured limbs it was 17.4° ± 6.7°, while in the uninjured limbs it was found that the average was 15.2 ± 5.2°. Moreover, the analysis of the data with the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between the injured and non-injured limbs.

The assessment of the plantar flexion of the ankle joint showed that in 13 cases of injured limbs (86.7%) we had values below the normal range and in 12 cases (80%) of uninjured limbs, we also had values below the normal range. The full range of motion in plantar flexion ranges from 45° - 50°, although in professional ballet dancers values above the full and normal range of motion have been observed (Russell, Kruse, Nevill, Koutedakis & Wyon, 2010). This is due to the continuous effort made by professional ballet dancers to improve the range of plantar flexion in order to meet the requirements of their activity (Hamilton, Hamilton, Marshall & Molnar, 1992). Regarding the symmetry between the two limbs, in five cases (33.4%) we had asymmetry. In four cases (26.7%), the injured limb was below the normal range of motion, while the uninjured limb had normal range of motion. In one case out of the total of three participants (6.7%) the injured limb had normal range of motion and the uninjured limb did not. Analysis of the data with the non-parametric Mann-Whitney U test showed that there were no statistically significant differences between injured and uninjured limbs.

5. Conclusions

In conclusion, we would say that the specific handball players in terms of anthropometric evaluation and more specifically in the measurement of the thigh and hip circumference showed a small percentage of asymmetry. This was presented exclusively in the thigh, while in the gastrocnemius the participants showed symmetry. Consequently, if the above fact is taken as a criterion, most athletes appeared ready for their safe return to the same competitive activity. In addition, at the measurement of hip flexion with flexed and extended knee, as well as at the measurement of knee flexion, in a percentage of 26.8% of participants were found asymmetric. Also, in terms of assessing the dorsal and plantar flexion of the ankle joint, the handball players of the sample showed asymmetry in 60% and 33.4% respectively.

Therefore, given that a significant percentage showed asymmetry in the measurements of the range of motion of the lower limbs, we would say that, from both anthropometric evaluation and ROM measurements, a significant percentage of the sample did not meet the specific criteria for safe return in the same competitive activity.

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