Isokinetic muscular strength of paralympic athletes with cerebral palsy (CP) from the Brazilian soccer team

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ABSTRACT

Introduction and objective: The muscle weakness, strength asymmetries and imbalance between antagonist muscles are risk factors for knee injuries. It is possible that these risk factors increase in soccer players with cerebral palsy (CP) due to their pathology and to the sport activity. Therefore, the objective of the present study was to assess the presence of these factors in paralympic athletes with CP from the Brazilian paralympic seven-a-side soccer team. **Methodology:** Twenty-one soccer players with CP and spastic hemiplegia were submitted to isokinetic muscle evaluation of their knees flexors and extensors muscles by means of the *Cybex* 6000 isokinetic dynamometer. The analysis of the muscle strength was performed with a peak torque at 60°/s. The study analyzed the contralateral deficit, the balance between flexor and extensor muscles and compared muscles weakness to the expected values for normal individuals (Neder et al. 1999). The paired t-Student test was used for the statistical analysis with $p < 0.05$. **Results:** The peak torque values of the involved flexors (FPT) and extensors (EPT) knee muscles (FPT = 88.4 ± 26.0 Nm and EPT 155.4 ± 37.2 Nm) presented significantly smaller ratios than those of the uninvolved ones (FPT = 116.2 ± 24.8 Nm and EPT = 201.6 ± 38.8 Nm). Only extensor muscles of the involved side were weaker than expected. However, the flexor muscles were weaker than expected in nine out of 21 individuals. The measures of strength of uninvolved knee muscles were not significantly different from the expected values. The average balance between flexors and extensors was within the normal range, although three individuals presented results below the normal range in the uninvolved side and nine of them in relation to the involved side. **Conclusion:** Highly trained soccer players with CP present increased risk factors to knee injuries derived from strength asymmetries, quadriceps muscle weakness and imbalance between antagonistic knee muscles. Thus, a muscular strengthening and evaluation program is highly indicated for this group.

Keywords: Peak torque. Knee injuries. Athletes.

INTRODUCTION

Cerebral palsy (CP) may be defined as a non-progressive disease that affects the development of the immature central nervous system (CNS)[1]. The spastic cerebral palsy is the most prevalent form[2,3] and is characterized by motor uncoordination, especially at the lower limbs that frequently involves functional activities. Many characteristics may be found among these patients such as: increase on the muscular tonus, loss of the selective muscular control and deficiency of the relations between antagonistic muscles strength of a given joint[1,4,5]. Fatigue and muscle weakness are characteristics also found in these patients[1]. The imbalance and muscle weakness symptoms have been described as cause of other worsening factors such as: muscle atrophy, joint contraction and eventual joint deformities. Thus, physical activities, especially the muscular strengthening have been prescribed for individuals with CP with the objective of reducing and eventually reverting some muscular damages[4].

Through the characteristics above, individuals with CP sequela require higher preventive cares during the performance of some physical activity.

Soccer is one of the paralympic sportive modalities indicated for individuals with CP, and the most prevalent form of palsy observed among athletes from the Brazilian paralympic soccer team is the spastic hemiplegia.

Soccer is the most popular sport modality worldwide with approximately 200 million players in 186 countries registered in the International Federation of Football Association, FIFA[6]. The incidence of injuries as result of the practice of this sportive modality ranges from three to seven injuries each 100 hours of training and from 13 to 24 injuries each 1.000 hours of game[7-12], and the knee joint is the second most involved with 17-23% of the total number of injuries[9,12,13].

Söderman *et al.*[14] investigated the risk factors associated with traumatic injuries of lower limbs among female soccer players. Among other factors, for example, the knee hyperextension and posture deviations, the authors found a positive correlation between the incidence of knee injury and a reduction on the strength relation between knee flexor/extensor (F/E) muscles during concentric contraction.

Devan *et al.*[15] studied the risk factors for lesion due to repetitive effort in female soccer players. These authors also found an increase on the knee joint injury incidence when the knee F/E muscles relation was low.

Duffey *et al.*[16] investigated the risk factors for anterior knee pain and found that the quadriceps muscle weakness is associated with anterior pain of the knee joint.

It is possible that paralympic athletes from the Brazilian soccer team, due to the CP disease and for playing soccer, present large incidence of risk factors for knee injuries.

We do not know about studies performed with the objective of evaluating the characteristics of the muscular strength relation between knee flexor and extensor muscles and the peak torque in paralympic athletes with CP. The knowledge on the presence of these muscular alterations could be very useful for coaches and physiotherapists to work in a preventive way with these athletes, minimizing risk factors and preventing the appearance of injuries. Thus the objective of the present study was to assess the following risk factor for knee injuries: weakness of the knee extensor and flexor muscles, imbalance between these muscles and the contralateral deficit between symmetric muscles in paralympic athletes from the Brazilian soccer team with cerebral palsy. The results obtained were compared with the expected values for the nonathlete population in general with the same anthropometrical characteristics.

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METHODS

Subjects

Twenty-one male athletes with spastic hemiplegia (26 ± 3 years of age) components of the Brazilian Soccer Team for athletes with cerebral palsy participated in this study. All individuals were submitted to previous clinical evaluation in order to confirm the spastic hemiplegia condition, no previous knee orthopedic injury, cardiovascular, respiratory, metabolic or neuromuscular disease (else than CP). A rest and effort electrocardiogram was performed before tests and all individuals were able to participate in this work. The tests were part of the medical-functional evaluation of the preparatory phase for the 2004 Athens Paralympic Games. The athletes signed a consent term after the explanations on the nature and risk of the tests.

Isokinetic muscular evaluation

Body mass and stature were measured in a digital scale (*Filizola*® PL Filizola, São Paulo, SP) with resolution of 100 grams and equipped with stadiometer. Before tests, all individuals performed warm-up exercises in stationary cycle ergometer (Metabolic System Bike – Cybex – Division of Lumex, Ronkonkoma, New York, USA) with duration of 10 minutes (constant load of 25 W, 70-80 rpm).

The isokinetic muscular evaluation was performed in a *Cybex 6000* isokinetic dynamometer (a Division of Lumex, Ronkonkoma, New York, USA) periodically calibrated according to recommendations from the manufacturer. The individual remained in sitting position and the equipment was adjusted for the ideal alignment of the knee joint to the center of the dynamometer and the trunk was fixed with the aid of a tree-point belt. The gravity correction procedure was previously performed. Later, the individuals performed three repetitions of the movement for the familiarization with the equipment. The individuals were then submitted to test composed of five maximal repetitions at 60°/s for the analysis of the peak torque (Nm). The muscular balance relation between knee flexor and extensor muscles was expressed as percentage (%).

The strength values expected for each muscular group were calculated using the predicting equations described in literature for healthy individuals[17].

Statistical analysis

The variables analyzed were expressed as average and standard deviation.

Considering the regular behavior of the variables evaluated by means of the Shapiro-Wilk test, we have used the t-Student test for dependent variables in order to evaluate the difference between expected and measured values and between values obtained by uninvolved limb and those obtained by limbs involved with hemiplegia. The significance level adopted was $p < 0.05$.

RESULTS

The athletes who participated in this study presented 26 ± 3 years of age, 173 ± 6 cm of height and 68 ± 8 kg of weight.

When the peak torque contralateral values measured for knee flexor and extensor muscles were compared, it was observed that the involved side was significantly weaker than the uninvolved one (figure 1), where the flexor muscles presented an average deficiency of 24 ± 12% and the extensor muscles of 23 ± 13%.

Figure 2 shows the averages of the percentile differences between peak torque measured and expected values of the flexor and extensor muscles. Only the knee extensor muscles of the involved lower limb were significantly weaker than the expected. However, one observes through table 1 that although the flexor muscles of the involved side presented significant weakness in relation to the expected, 11 individuals presented deficiency above 10% (values in boldface of table 1).

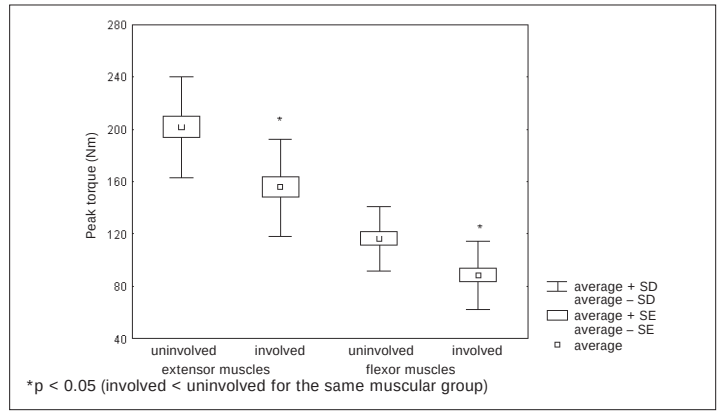

Fig. 1 *– Graphic representation of the average values, standard deviations and errors and peak torque (Nm) measured of knee flexor and extensor muscles of the involved and uninvolved side of soccer players with spastic hemiplegia*

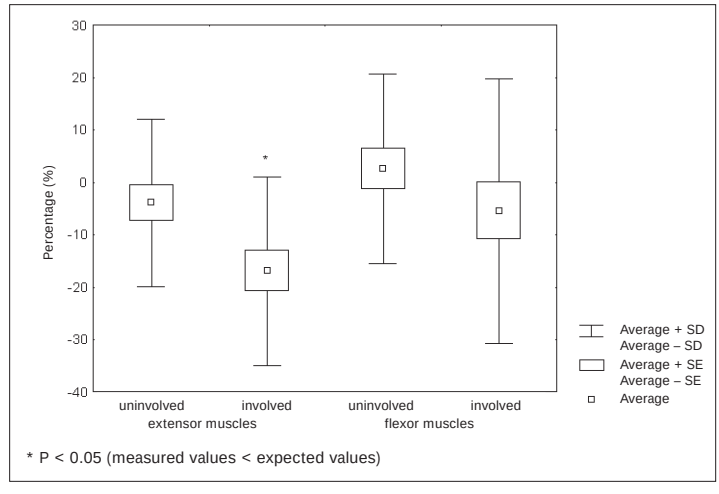

Fig. 2 *– Graphic representation of average, standard deviations and errors of percentage differences (%) between measured and expected values of peak torque of flexor and extensor muscles of the involved and uninvolved knees of soccer players with spastic hemiplegia*

In relation to the peak torque values obtained from the uninvolved side of both muscular groups, no significant difference for any variable was observed in relation to the expected, although nine individuals presented weakness above 10% (underlined values of table 1).

The muscular balance relation between knee flexor and extensor muscles was of 57.2 ± 7.5% and 57.6 ± 18.6% in involved and uninvolved limbs, respectively. Although these average values are within normal range (50-70%[18]), 12 relations measured were found below 50% (table 2).

DISCUSSION

The muscular strength has demonstrated to play important role in the adequate neural control for individuals with CP as well as for other pathologies involving the upper motor neuron[19,20]. Moreover, the muscular strength, the contralateral deficit and the imbalance between antagonistic muscles of a given joint are considered as risk factors for the development of injuries of the locomotive system, especially when these factors are associated with physical activity. Data on the incidence of these risk factors in individuals with cerebral palsy who play soccer are not found in literature, sport modality indicated for these patients and one of the most popular worldwide.

TABLE 1
Percentile difference (%) between measured and expected peak torque values for knee flexor and extensor muscles of the involved and uninvolved side of soccer players with spastic hemiplegia

Athletes	Extensor muscles		Flexor muscles	
	Uninvolved	Involved	Uninvolved	Involved
1	11.3	–10.1	42.9	22.9
2	–11.3	–16.8	9.2	–2.9
3	–14.6	–8.2	–9.4	–6.4
4	7.9	–7.3	15.7	18.0
5	2.4	–35.6	0.0	**–20.2**
6	23.8	5.9	23.9	32.2
7	–11.4	–14.4	15.0	35.9
8	–15.6	–55.4	0.0	16.2
9	–11.9	–26.7	5.0	**–25.8**
10	1.5	–14.5	–5.6	**–30.1**
11	–2.0	0.6	12.8	3.3
12	9.7	–7.0	–8.6	**–12.2**
13	–35.5	–36.0	–43.4	**–50.6**
14	–16.8	–2.5	–15.0	**–21.4**
15	–7.6	–28.0	0.9	**–24.2**
16	–23.4	–27.9	–1.7	–1.1
17	–22.6	–40.5	–13.2	**–43.7**
18	24.7	23.8	32.5	40.0
19	–0.5	–10.6	–2.7	**–15.6**
20	18.5	–9.3	–4.3	**–14.7**
21	–8.2	–33.5	0.0	**–12.8**
Average	–3.9	–16.9	2.6	–5.4
Standard deviation	15.9	18.0	18.1	25.2

Underlined values represent the weakness values in relation to expected of the dominating side above 10%.
Boldface values represent the deficiency values in relation to the expected above 10%.

TABLE 2
Balance relation (%) between peak torque of knee flexor and extensor muscles of the involved and uninvolved side of soccer players with spastic hemiplegia

Subjects	Involved	Uninvolved
1	68	66
2	65	58
3	56	**48**
4	57	62
5	53	61
6	53	60
7	69	77
8	63	126
9	63	**46**
10	50	**42**
11	62	52
12	**44**	**49**
13	**47**	**39**
14	55	**42**
15	58	52
16	68	64
17	60	**47**
18	57	56
19	52	**47**
20	**43**	**46**
21	59	70
Average	57.2	57.6
Standard deviation	7.5	18.6

Boldface values represent relations below normal range.

The present work evaluated the knee muscular function in paralympic soccer players during the pre-competition period in order to investigate the presence of risk factors for knee injuries.

The muscular weakness was investigated by means of the comparison of the measured peak torque values in relation to the expected values[17] for healthy individuals with same gender, age and body dimensions.

The presence of average values significantly lower than the expected ones for knee extensor muscles of the involved lower limb shows that the soccer practice is not sufficient to compensate the loss of muscular strength in individuals with CP. The individual analysis shows that only three out of the 21 individuals studied, according to the clinical criteria adopted in our study, presented no weakness on the knee extensor muscles (difference above 10% between measured and expected values). It is possible that individuals with lower degrees of spastic hemiplegia have achieved reverting the muscular weakness condition due to the disease in the quadriceps muscle.

Duffey *et al.*[16] demonstrated that the quadriceps muscle weakness is associated with the incidence of anterior knee pain. Thus, most athletes studied in this work presented increased risk for this symptom.

In relation to the flexor muscle of the involved lower limb, despite the non-significant difference between averages of obtained and expected values and according to the clinical criterion, 11 individuals presented weakness on the ischiotibial muscle of the involved lower limb (values in boldface of table 1). It is possible that this lower number of individuals with involvement of the knee flexor muscles is an evidence of the involved limb response to the soccer practice. Cometti *et al.*[21] showed that professional soccer players present stronger flexor muscles in relation to amateur soccer players, but the same behavior was not observed for the extensor muscles.

The absence of statistical difference between measured and expected values for the muscular strength of knee flexor and extensor muscles of the involved lower limb in these individuals could be considered as an evidence of the benefits obtained from the soccer practice, once Wiley and Damiano[22] described bilateral weakness of several muscular groups in children with CP. However, differences between the CP characteristics of individuals from both studies can also explain differences between our results and results obtained by those authors.

Moreover, despite the average muscular strength values of flexor and extensor muscles of the uninvolved limb are not different from the expected values, nine individuals presented values below 90% of the expected (underlined values of table 1).

The strength contralateral difference of muscles involved with hemiplegia is a characteristic of CP[2]. The values observed (24 ± 12% for flexor muscles and 23 ± 13% for extensor muscles) are lower than those observed by Damiano and Abel[4] in children and adolescents with spastic hemiplegia. The lack of information on the characteristics of the group studied by Damiano and Abel[4] or of a control composed of sedentary individuals with cerebral palsy paired according to gender and age in the present study limit the performance of a deeper analysis of the effect of the soccer practice on the muscular deficit due to CP.

The analysis of the strength relation of knee flexor and extensor muscles presented average values within normal range of 50 – 70%[18] in the involved knee (57 ± 19%) and in the uninvolved knee (57 ± 6%). However, for the individual analysis of results, we have observed that nine individuals presented low relation in the involved knee and three individuals in the uninvolved knee (values in boldface in table 2). These low relations observed in these 12 cases demonstrate weakness on the flexor muscles in relation to their antagonistic muscles; this muscular imbalance may be considered as causal factor of damage on the knee stability[23], with increased risk of knee injury both due to traumas[14] and due to repetitive efforts[15].

This study presents some limitations. The time the athletes were available for tests did not allow the performance of other measurements in order to evaluate the risk of injuries in other joints. The results obtained do not allow estimating the presence of risk of knee injury in soccer players with cerebral palsy, with lower training load. We could only verify the necessity of higher attention in

relation to the preventive aspects regarding paralympic soccer players with CP.

The present study represents first evidence in literature that soccer players with cerebral palsy, even highly trained, may present high risk of knee injuries due to trauma or to repetitive efforts. Such risk would be associated to the presence of muscular weakness, strength asymmetry and imbalance between knee flexor and extensor muscles. Therefore, one recommends that such individuals should be submitted to muscular strengthening programs, regardless the training degree or stage and that these programs should be elaborated based on specific evaluations, once the muscular involvements are not uniform for different patients and muscular groups.

All the authors declared there is not any potential conflict of interests regarding this article.

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