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The postural impact on the prevention of injuries in young basketball players: A longitudinal preliminary study

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Abstract: The competitive sport practice is a well-known risk factor for juvenile Low Back Pain and other common injuries. The present research aims to introduce a prevention protocol in the two-years training program of a young Italian basketball team. The results are encouraging and demonstrate the importance of supporting the motor development of the young athletes.

Keywords: Posture; Prevention; Basketball; Children; Low back pain

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Introduction

The posture is worldwide considered like the way our body faces the external stimuli like gravity or instability. Furthermore, it influences our ability to move and our way to behave. By influencing the motor skills this is also a necessary aspect to consider preventing injuries, like the Low Back Pain (LBP). This is a common muscle-skeletal disorder, which also impacts on children and adolescents. Watson (2002) [1] affirms that the incidence of LBP is similar in adolescents and adults. In the scholar population, the prevalence is age-related, in particular, it doubles from 12 until 15 years of age. Calvo-Muñoz and colleagues (2013) [2] confirm that 61.7% is the prevalence of LBP in the under18 population. The presence of LBP in the young population is completely linked to the presence of the risk factors. Hill and colleagues (2010) [3] found out 47 risk factors for LBP. Anyway, the author affirms that is rarely possible to identify a clear correlation between risk factors and LBP. Evidence about the correlation between LBP and risk factors in the young population is a little; furthermore, sometimes there are controversial outcomes, because of a lack of follow-up research. Nevertheless, European Guidelines (2006) [4] suggest that LBP depends on lifestyle-related, school-related, psychosocial-related, and physical-related risk factors, i.e. obesity and sedentariness. Cairney[9] affirms that hypo-activity is involved in a continuous negative feedback loop in relation to motor coordination and physical fitness. Referring to Hands and colleagues (2002) [5] and Wall's (2004) [6] theories, Cairney demonstrates that obesity and overweight can lead to inactivity and sedentariness [7]. Inactivity itself can lead to poor coordination and poor fitness, which mean to have, for instance, children with tight and inflexible muscles, or with poor aerobic training. All these relations are bidirectional and influence on each other. All the conditions are a risky factor to develop disorders or injuries, like juvenile LBP. It could seem controversial, but the European Guidelines (2006) also affirm that the sport practice doesn't clearly protect the young population from the LBP. In fact, in their review, Balagué, Troussier and Salminen (1999) [8] report a lot of studies, where a correlation between the incidence of LBP and intense competitive sport practice emerges. For instance, Taimel [9] and colleagues found out this correlation in a sample of 1171 children aged between 7 and 16 years old. Balagué and colleagues [9] found out the same result in a sample of 1700 children, aged between 8 and 16 years old. The review identifies in particular basketball, volleyball, and soccer -but practised at a competitive level- as a risky activity. Skoffer and colleagues (2008) [10] evaluated 546 adolescents 15-16-years-old. The practice of impact team-sport influences the prevalence of LBP. We can assume that the literature is controversial on this topic, but it is clear that physical activity is necessary, if appropriate and well managed for the children. Probably the competitive team-sport practice has a strong impact on the body of the children, on their posture, and on their way to move. Fett and colleagues (2017) [11] demonstrated that the LBP prevalence increases in young athletes who practice sport at a competitive level. The European Guidelines also highlight the impact of physical factors, as risk factors. The evidence is a few also for this topic, but Feldman and colleagues (2001) [12] affirm that muscles tightness (in particular of hamstrings) and reduced trunk strength and stability are risk factors for LBP, both in adults and adolescents. Cardon and Balgue (2004) [13], and Burton and colleagues (2014) [5] also support this assertion.

In this study, we propose an LBP prevention protocol for pre-adolescents and adolescents who are practising basketball at a competitive level. We propose training for specific abilities, those should permit the children to improve their posture, their way to move and to prevent LBP. We aim to have an impact on some risk factor to improve the way the children move. To verify our aim we use photogrammetric software to assess the posture of the sample. The modification of the posture could lead to a better ability to move, to a better body balance (in terms of muscles length and strength), both necessary to prevent LBP.

Materials and Methods

The Ethics Committee of the University of Trieste approved this study. All the parents of the children read and signed the written informed consent. This is a longitudinal study, which considers the same population between September 2016, and June 2018 (two basketball seasons). The players were recruited in a basketball Club of Trieste (Pallacanestro Interclub Muggia). In this club, the young players afford 3 trainings a week and already play the games versus other Clubs. They play basketball at a competitive, intense level.

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The study develops in different stages.

Stage 1 - first photogrammetric assessment on September 2016.
Stage 2 - proposal of weekly prevention protocol for LBP and common injuries. They practice this protocol with a physiotherapist for 30 minutes, during the basketball training.
Stage 3 - second photogrammetric assessment during summer 2017.
Stage 4 - same proposal of the prevention protocol.
Stage 5 - last photogrammetric assessment on June 2018.

The players were monitored for their physical health, by constantly asking them about injuries or accidents. The informed written consent, and participating in the training 3 times a week were inclusion criteria. Acute or chronic LBP is an exclusion criterion because the study aims to prevent it. Other acute injuries excluded the participants if they were not able to afford the first assessment. For the ethical reason, the sample is not randomized because we proposed the protocol to the entire team.

Population

86 young players (50 males, 36 females) from the same basketball Club were recruited. They were born between 2004 and 2008 The sample practiced the protocol during the basketball training, and it was divided for age in this way: 18 males born in 2004/2005 (6,12), 17 males born in 2006/2007 (5,12), 15 males born in 2008, 8 females born in 2004, 14 females born in 2005/2006 (5,9), 14 females born in 2007/2008 (9,5). 5 children were excluded because of LBP or neck pain during the first assessment, or before. 14 children were excluded because they play basketball less than 3 times a week. 4 children didn't receive the consent from the parents to participate. 2 children didn't afford the final assessment because of an acute injury, and 2 children left the basketball practice. At Stage 3, the sample consisted of 59 children (32 males, 27 females). During the last sport season, 20 athletes moved to another team or left the basketball practice. 1 child was absent during the period of the final assessment. The final sample consists of 38 children (25 males, 13 females), mean age=11.68 (SD=1.51)

Procedure

We propose an anamnestic questionnaire and a photogrammetric assessment through the validated digital system of postural analysis SAPO (Ferreira, 2010) [14]. We put markers the following point: tragi, spinal process of C7, T3, T7, L1, L3, L5, anterior-superior iliac spines, posterior-superior iliac spines, femurs (greater trochanter), knees (articular line), patellae (medium point), legs (point a medial line), calcaneal tendon between malleolus, and malleoli. To mark the points, we positioned styrofoam balls (15 cm circumference) using double-faced adhesive tape. The camera (Nikon Coolpix L100) was placed on tripods (height of 1.50) with an angle of 90 degrees (same distance). The camera was placed 2 meters from the subject. A plumb line marked with two styrofoam balls was used for vertical calibration. We took 8 pictures for each subject: anterior frontal standing, posterior frontal standing, left-side sagittal standing, right-side sagittal standing, right-side sagittal forward bending, posterior frontal view of the feet, left-side sagittal view of one-foot, right-side sagittal view of the other foot. In all the assessing stages we took the same number of pictures. We used a reserved calm place of the gym during the basketball training. Then, we analyzed the pictures through the software SAPO v0.68 in the Physiotherapy University of Trieste.

Referring measurements

We refer to literature to verify the postural situation of the sample. The considered measures are the Cranio-Cervical Angle (CCA), the Lumbar-Pelvic Angle (LPA), the Tibio-Tarsal Angle (TTA), the Curved Knee Angle (CKA), the Varus/Valgus knee Angle (VVA), the Arch Index (AI), the Forward Bending Index (FBI).

- The CCA is composed by the intersection between the horizontal line which passes through C7, and the intersection line which touches C7 and the tragus. 51.25° is the cut-off value to discriminate a physiological head position or a forward head (<51.25°) [15].
- The LPA is considered in forward bending. It is composed by the intersection between the line, which touches the anterior-superior iliac spine and the posterior-superior iliac spine, and the line, which touches the great trochanter and the articular line of the knee. Whether the angle is < 12.6° the hamstrings are considered elastic. The angle included between 12.6° and 22.5° refers to a normal elasticity of the hamstrings. The angle > 22.5° defines stiff hamstrings. This is an important value to consider in the incidence of LBP [16].
- The TTA is considered in forward bending. It is composed by the horizontal line, which touches the lateral malleolus and the line, which passes through the articular line of the knee and the lateral malleolus. The TTA >90° determines stiffness in hamstrings and ankle [17].
- The CKA is the angle between the line, which touches the great trochanter, and the articular line of the knee, and the line, which touches the articular line of the knee and the lateral malleolus [18]. The cut-off value is 185° [19].
- The VVA is composed by the intersection of the line, which passes through the anterior-superior iliac spine and the medium point of the patella, and the line, which passes through the medium point of the patella and the lateral malleolus. The cut-off value to consider a valgus knee is 174.5° [20].
- The AI comes from the relation between the length and the height of the plantar arch. The AI>6.74 defines a flat foot [21].
- The FBI id the distance between the finger and the sole during a forward bending. It is correlated to the elasticity of the hamstrings. The cut-off value is 15cm [22].

Treatment protocol

To create the prevention protocol, we took into account the first assessments we did. Considered as physical risk factors for LBP, we decided to aim to modify the following variables: the hamstrings elasticity, the angles of the knee, and the stiffness of the whole back. We also included important aspects of core-stability to intervene on the way the children use their body and their posture to move and play.

The protocol consists in:

- global active stretching (SGA - sitting with legs extended, standing with the body on the wall or in forward bending [23], closing LPA, 5');
- selective stretching (rectus femoris, psoas, adductors, 1' each);
- one/two-legs bridge exercise (20 repetitions each);
- horizontal and lateral plank (2 times for 20");
- medium gluteus, abductors side exercises (20 repetitions each)
- one-foot-standing with/without dynamic movements, and open/closed

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eyes (1' each exercise, in a total of 5/6');

- split squat, side squat, wall sit (2 times for 20" each);
- feet rapidity exercises (2' each).

The prevention protocol was proposed for 30' one time a week, before the children begun the basketball training. We proposed the same exercises in both basketball seasons. The protocol had been produced and proposed by a physical therapist, which assisted, corrected and helped the children. In all the activity the physical therapist remembered to the children to pay attention at the position of their knees, of their backs, and of their feet.

Limitations

The small number of participants, not having a control group, and not continuing the protocol during the summer holidays, are all limits of this study. Nevertheless, these aspects are all due to the organization of the proposal, which involved just one basketball Club. We are working to solve these problems in the immediate future.

Results

These data emerge from the assessment and the elaboration made through the digital software SAPO. In the following paragraphs we are going to show the results of the entire sample; then gender, age, and speed of growth stratifications are provided. The following Table 1 shows the p-value about the postural evaluation (Wilcoxon Test). The following data show the impact of the prevention protocol on the participants' posture. The p-values demonstrate some significant difference between the three stages of the study. The following Table 2 describes the posture of the participants during this longitudinal study.

To exclude the influence of the height growth on the postural improvements, we provide a stratification of the sample considering the speed of growth. The following Table 3 shows the postural attitude of the children grown more than 9 cm (9cm=median of growth) in one year, compared to the others. We just provide data about the last period of study (between Stage 3 and Stage 5). Also, in this part of the analysis, a comparison between populations has not been provided because of the descriptive purpose of this assessment.

Finally, we propose a comparison between the older and the younger participants is here provided. Table 4 shows the cross-sectional study (Mann & Withney Test) of the children born in 2007 and 2008 (younger), and the children born in 2004, 2005 and 2006 (older).

Taking into account the previous data, we have provided an assessment of the complete sample, followed by a more specific evaluation, which considered some peculiarities of the subjects.

Discussion

The aim of this study was trying to intervene in children's posture by proposing a prevention protocol during the basketball training. Teaching specific abilities, strengthening and stretching different muscles we would improve the children's posture and way to move. We focused on exercises, which could help to reach a balanced body (in terms of muscles length and strength), extremely necessary to prevent LBP and other muscle-skeletal injuries. The statistical analysis, described in Table 1, shows the significant modification between the beginning and the end of this study (Stage 1 - Stage 5) of LPA (p-value=0.0020), right VVA (p-value=0.0388), left CKA (p-value=0.0250), TTA (p-value<0.0001), and left AI (p-value=0.0206).

The LPA improves during the two years of intervention, in fact, the 78.95% of children with stiff hamstrings -opened LPA- becomes

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52.63% at Stage 3 and 42.11% at Stage 5. The global and selective stretching seems to impact on the elasticity of the hamstrings. According to Belanguè and colleagues, closing the LPA could reduce one of the risk factors for the LBP. Even if the statistical analysis (Table 1) suggests that the right VVA statistically differs from the Stage 1 to the Stage 5, for all the duration of the study the percentage of children with the right valgus knee stacks at 94.74% (Table 2). This outcome can't be considered as positive, also because the left VVA doesn't improve in the time, even if the percentage goes from 97.37% to 94.74%. Totally, the 94.74% of the participants has both valgus knees. The dynamic movements, the strengthening of gluteus and quadriceps, the stretching have not been sufficient to bring a modification on the attitude of the knees. This outcome is worrying because of the many injuries linked to the valgus attitude of the knees, like for example the Anterior Cruciate Ligament injury (Hewett, 2010) [24] or osteoarthritis (Lerner, 2015) [25]. According to Olsen (2005) [26], the sport practice can increase the risk of knee injuries, because of the mechanical stress that the joints are suffering. The protocol we proposed had been a reduced impact on this problem. More efforts and exercises should be included to have a satisfying result on the knees orientation. We also suppose that early cognitive training could teach the children how to move their lower limbs, consequently influencing these outcomes. Still considering the knees, the left CKA improves during the study and the percentage of children with a curved left knee reduces from 60.53% to 34.21% (Stage 3=42.22%). In statistical terms, the right CKA remains constant during the study. The qualitative analysis (Table 2) demonstrates that the percentage reduces also for the right knee (39.47% Stage 1; 34.21% Stage 3; 21.05% Stage 5). We can affirm that the proposed protocol had been useful to reduce the curved knee in the participants but not the valgus attitude.

The statistical analysis (Table 1) shows that the TTA modifies with an extremely significant p-value (<0.0001). Considering the cut-off value, we know that a TTA>90° means stiff hamstrings. Even if the p-value suggests a large improvement in this joint, in Stage 1 and Stage 3 the joint range of the ankle is almost never lower than 90° (Stage 1=93.5°-105.3°; Stage 3=91.1°-108.4°; Stage 5=89.7°-103.9°). A consistent improvement has taken place, but it is not enough to bring the participants below the cut-off; in fact, the percentage of children with an opened TTA (stiff hamstrings) changes just from 100% to 97.37%. We can affirm that the hamstrings stiffness changings are especially due to the large LPA improvements than the reduced TTA modifications. This means that the prevention protocol should be implemented to improve the elasticity of the complete lower limb. The left AI significant p-value demonstrates an improvement of the foot posture. The right AI p-value of 0.0520 is not statistically significant, however, it is very close to the 0.05 p-value cut-off (Table 1). In fact, it is interesting that the percentage of children with flat foot has been reduced for both feet. In particular the percentage changes from 28.95% to 21.05% for the right foot, and from 42.11% to 26.32% for the left foot (Table 2).

The CCA and the FBI don't have a statistical improvement between Stage 1 and Stage 5, but they show significant p-values during the intermediate stages of the study. The CCA gets worse in the first part of the study with a negative p-value of 0.0001, but improves between Stage 3 and 5 with a positive p-value of 0.0001 (Table 1). The starting worsening is not clear, but it is possibly due to the beginning difficulties of the children in practising the exercises. In fact, the incorrect position of the head during the exercises was one of the most important compensation during the first part of the study. By practising the exercises, the children have been able to improve this aspect.

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Table 1: Emerging results from the postural assessment through the photogrammetric software.

Posture	Range Stage 1	P-value St.1-3	Range Stage 3	p-value St.3-5	Range Stage 5	p-value St.1-5
CCA	27.2°-54.7°	(-) <0.0001**	26.9°-53.4°	<0.0001**	29.9°-53.9°	0.9999
LPA	11.3°-59.4°	<0.0001**	5.4°-36-6°	0.4153	4.6°-40.2°	0.0020**
Right VVA	158.3°-175.2°	0.0049**	160.3°-178.5°	0.7713	162.1°-176.5°	0.0388*
Left VVA	156.8°-174.7°	0.021*	160.2°-176.5°	0.4084	162.2°-175.8°	0.5281
TTA	93.5°-105.3°	0.1263	91.1°-108.4°	0.0368*	89.7°-103.9°	<0.0001**
Right CKA	174.2°-195.8°	0.0678	175.8°-192.9°	0.7885	172.5°-190.5°	0.1017
Left CKA	169.8°-196.0°	0.0132*	177.7°-196.9°	0.4209	175.9°-195.2°	0.0250*
Right AI	3.0-13.0^	0.0026**	2.89-7.16^	0.1553	3.27-7.36^	0.0520
Left AI	3.17-14.10^	0.0042**	2.95-8.92^	0.5668	2.97-7.32^	0.0206*
FBI	0.0-28.3 cm	0.0005**	0.0-16.9 cm	(-) <0.0001**	0.0-26.8 cm	0.0972

Cranial-Cervical Angle, Lumbar-Pelvic Angle, Varus/Valgus knee Angle, Tibio-Tarsic Angle, Curved Knee Angle, Arch Index, Forward Bending Index. *significant outcome; **extremely significant outcome; (-)negative difference; ^absolute value.

Table 2: Qualitative analysis of the postural changing in the sample.

Posture	Stage 1	Stage 3	Stage 5
CCA	89.47% forward head	97.37% forward head	86.84% forward head
LPA	78.95% stiff hamstrings	52.63% stiff hamstrings	42.11% stiff hamstrings
Right VVA	94.74% valgus	94.74% valgus	94.74% valgus
Left VVA	97.37% valgus	94.74% valgus	94.74% valgus
TTA	100% stiff	100% stiff	97.37% stiff
Right CKA	39.47% curved	34.21% curved	21.05% curved
Left CKA	60.53% curved	42.11% curved	34.21% curved
Right AI	28.95% flat foot	13.16% flat foot	21.05% flat foot
Left AI	42.11% flat foot	16.32% flat foot	26.32% flat foot
FBI	89.47% stiff hamstrings	97.37% stiff hamstrings	81.58% stiff hamstrings

Cranio-Cervical Angle, Lumbar-Pelvic Angle, Varum/Valgum knee Angle, Tibio-Tarsic Angle, Curved Knee Angle, Arch Index, Forward Bending Index. Values expressed in percentages (of participants).

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In fact, the percentage of children with a forward head position decreases from 89.47% at Stage 1 to 86.84% at Stage 5 (Table 2). For the FBI the pathway has been the opposite and the improvement came up at Stage 1 with a p-value of 0.0005. We can justify this outcome because at the beginning the children themselves concentrated a lot on the FBI because they would improve their "personal record" decreasing their own hand-floor distance. In the second part of the study, their attention on this aspect decreased (negative p-value of 0.0001). However, the percentages of children with a wide FBI decrease from 28.95% at Stage 1 to 21.05% at Stage 5.

Considering the qualitative analysis (Table 2), we can definitely affirm that the participants improve their postural attitude for the entire considered items. The two-years-long assessment demonstrates changes in the sample. Between Stage 1 and Stage 5 the percentage of participants with the forward head attitude reduces from 89.47% to 86.84%. The stiffness of the hamstrings reduces: from 78.95% to 42.11% of the sample considering the LPA; from 100% to 97.37% considering the TTA; from 89.47% to 81.58% considering the FBI. The right knee always remains valgus for the entire duration of the study in 94.74% of the participants. For the left knee instead, the percentage decreases from 97.37% to 94.74%. The curved knee affects from 39.47% to 21.95% of the participants in the right limb, and from 60.53% to 34.21% in the left knee. The AI, -representing the flat feet posture- reduces from 28.95% to 21.05% in the right foot, and from 60.53% to 34.21% in the left foot. This postural attitude improvement is an important goal for a longitudinal prevention program. However, the lack of a control group remains a consistent issue in order to define the real validity of this protocol. Taking into account references of Belagué et al. [9] and Skoffer et al. [11], the basketball practice is considered a risky factor for several injuries. This activity has also an impact on the postural attitude of the athletes. For these reasons we could assume that proposing the prevention exercises could lead to a postural benefit indeed. In a high specific sport practice, the proposal of global and active stretching, of stability and balance exercises could just enrich the activity itself.

In this study, we consider the speed of growth as possible influence factor (Table 3), which could have an impact on the postural development of the participants. Considering the last part of the study, we provide the p-values about the postural attitude of the stratified sample. The entire sample (rapidly and normally growth participants) shows a significant improvement in CCA and a negative change in FBI. There are no differences between the two groups. From these outcomes we can affirm that the growth rapidity doesn't have an impact on the postural attitude of the participants. To verify the impact of a quick growth on the postural attitude, this analysis is necessary; nevertheless, a cross-sectional study a cross-sectional study is not provided, because my aim is to describe the peculiarities of the subgroups and not to strictly compare them.

The last stratification that we propose divides older and younger participants. We provide a cross-sectional study of these samples to assess the postural development during different evolutional phases (Table 4). The two groups compare for several items. However, at Stage 1 they differ in the left AI (p-value=0.019), and at Stage 3 they differ in the FBI (p-value=0.0048). The data demonstrate that the younger participants are closer to the physiological cut-off for both the items. At Stage 5, the older participants demonstrate a smaller incidence of VVA for both the knees (right p-value=0.0241; left p-value=0.0242). This comparison highlights that there are no large differences in the postural development of younger and older participants. Anyway, the symmetric improvement of the older sample in the valgus knee, suggests that in this sample the correct postural knee adaptation is reached closer to the 14 years of age. This outcome could have interesting implications on the choice of the exercises to propose in a prevention program.

Table 3: emerging data about the population considering the speed of growth.

Posture	Rapid growth (>9cm in 1 year)	Normal growth (<9cm in 1 year)
CCA	0.0250*	00014**
LPA	0.9399	0.7012
Right VVA	0.4263	0.2290
Left VVA	(-) 0.0739*	0. 9729
TTA	0.1928	0.1470
Right CKA	0.4332	0.2722
Left CKA	0.4332	0.1907
Right AI	(-) 0.0833*	0.8117
Left AI	0.5619	0.8949
FBI	(-) 0.0574 *	(-) 0.0002**

Cranial-Cervical Angle, Lumbar-Pelvic Angle, Varus/Valgus knee Angle, Tibio-Tarsic Angle, Curved Knee Angle, Arch Index, Forward Bending Index. Rapid growth=children growth more than 9 cm in one year. Normal growth=children growth less than 9 cm in one year. *significant outcome; **extremely significant outcome; (-)negative difference.

Table 4: Cross-sectional study after age stratification (younger and older).

Posture	p-value Stage 1	p-value Stage 3	p-value Stage 5
CCA	0.5859	0.1733	0.0873
LPA	0.6607	0.7392	0.1932
Right VVA	0.6828	0.2145	0.0241* (o)
Left VVA	0.6828	0. 1639	0.0242* (o)
TTA	0.3719	0.8917	0.5550
Right CKA	0.5859	0.5551	0.2091
Left CKA	0.8559	0.4137	0.7278
Right AI	0.0874	0.8205	0.3884
Left AI	0.019* (y)	0.9879	0.7853
FBI	0.0609	0.0048** (y)	0.5524

Cranial-Cervical Angle, Lumbar-Pelvic Angle, Varus/Valgus knee Angle, Tibio-Tarsic Angle, Curved Knee Angle, Arch Index, Forward Bending Index. (o)=larger improvement in the older participants. (y)=larger improvement in the younger population. *significant outcome; **extremely significant outcome.

Conclusion

The present study demonstrates that the proposed prevention protocol have produced small postural quantitative changes in the sample; anyway, the qualitative assessment highlights several differences about the postural attitude of the entire sample. The qualitative modifications are the starting point in order to increase the motor abilities, and to improve the basketball performances of the participants.

In order to deepen the specific impact of this prevention program, in the future, we aim to introduce a control group. In the meantime, we can affirm that the introduction of such a protocol of stability, stretching, balance exercises could help sporty children to reduce the risk factors for muscle-skeletal injuries indeed.

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