PHYSICAL ACTIVITY-RELATED INJURIES PREVENTION INTERVENTION STUDIES REPORT

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Physical activity-related injuries prevention in adolescents

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PHYSICAL ACTIVITY-RELATED INJURIES PREVENTION IN ADOLESCENTS (PARIPRE)

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ABSTRACT

INTRODUCTION:

Participation in youth sports, offers numerous physical, social, and psychological benefits for young individuals (Eime et al., 2013). However, the intensity and physical demands of sports participation can also expose young athletes to an increased risk of sports-related injuries (Andreoli et al., 2018). One of the most popular and widely practiced sports around the globe are basketball and football, known for its dynamic nature, high-physical demands in both the offensive and defensive playing, including activities such as sprinting, jumping, rapid changes of direction, and often physical contact with opposing players (Ferioli et al., 2018; Stojanović et al., 2018). These characteristics place considerable stress on the musculoskeletal systems of young athletes, who are still in the phase of growth and development. As a result, they are particularly susceptible to various types of musculoskeletal injuries, including sprains, strains, ligament tears and overuse injuries (Andreoli et al., 2018; Doherty et al., 2014; Jayanthi et al., 2022). Among the various preventive approaches, neuromuscular training (NMT) has emerged as a promising strategy for reducing injury incidence among athletes (Ageberg et al., 2020; Brunner et al., 2019; Talpey & Siesmaa, 2017). Previous research has shown that NMT interventions are effective in decreasing the overall injury rates and lowering the severity of injuries (Brunner et al., 2019; Lutter et al., 2022; Stephenson et al., 2021). However, low adherence and maintenance of injury prevention programs are among major issues (Åkerlund et al., 2022, 2023; Benjaminse & Verhagen, 2021; Steffen et al., 2013). Therefore, the aim of the presented study was to evaluate several aspects of a targeted NMT intervention in adolescent basketball and football players implemented during their training practice and competition on: i) injury incidence, ii) neuromuscular function; iii) adherence, maintenance and acceptance of intervention.

METHODS:

<u>Participants:</u> Two-hundred seventy-five male adolescent basketball players (Table 1), from 20 Slovenian competitive teams (under 15-year groups and under 17-year groups), were recruited for the study. Ten teams were randomized in an intervention group (IG) while other remained in a control group (CG).

Research sample in the football part of study consisted of 237 young players (Table 1) from 17 teams (9 sport clubs) included in the group of young talented teams according to Slovak Football Association (competitive categories Under 13 and Under

15, age between 12 – 15 years). Nine teams were assigned to the intervention group (IG) and other eight teams to the control group (CG). Allocation was done by randomisation. All teams of the same club were randomized into the same group (clustered allocation with the club serving as a cluster) to minimize the risk of contamination of the intervention results.

Table 1. Basketball and football participants of the study.

	Basketball			Football		
	Intervention group	Control group	p-value	Intervention group	Control group	p-value
N	129	146		125	112	
Age / years	15.0 (1.6)	15.1 (1.7)	.436	13.7 (1.1)	13.8 (1.0)	.670
Body height / cm	174.6 (9.9)	175.2 (12.9)	.652	164.7 (10.3)	166.7 (11.0)	.153
Body mass / kg	65.1 (13.1)	64.4 (16.6)	.701	52.0 (10.3)	55.8 (12.4)	.010
Body mass index / kg/m2	21.2 (3.2)	21.0 (7.4)	.736	19.0 (2.3)	19.9 (3.1)	.011

Study design: The basketball RCT was approved by Ethical committee at Science and Research Center Koper (No. 0624-9/22; 2.2.2022). The football RCT was approved by The Ethics Committee of the University of Prešov (ECUP032022PO). The study design is described in detail elsewhere by Šimunič et al. (2021).
Assessments: All conducted assessments are described in detail elsewhere by Šimunič et al. (2021).

Statistics: After confirming normality and homogeneity a mixed linear modelling was used for every study outcome. Participants were classified as random factor, whereas group (IG and CG) and time (BDC, POST) were classified as fixed factors. If significant main interaction effect (time * group) was observed, a post-hoc analysis with Bonferroni correction of p-value was applied to compare time effects in each group separately. All statistical decisions were made at $p \leq 0.05$.

RESULTS:

Basketball: The IG conducted an average of 16.3 NMT sessions during the 3-month intervention period, with an adherence rate of 91.1%. Both groups improved their balance following the intervention period, however no difference was observed between groups. The majority of Tensiomyography-derived skeletal muscle contractile parameters showed positive alterations following the intervention regardless of group allocation (Table 2). Compared to CG, IG experienced larger decrement of delay time in vastus lateralis (VL), unchanged values in gastrocnemius medialis (GM) and biceps femoris (BF) while in CG delay time increased at POST. Additionally, in IG contraction time of the GM remained at POST as it was in BDC, while it increased in CG.

Injury prevalence was higher in CG (23.3 %) when compared to IG (10.9 %). The injury incidence rate was 0.91, 1.01 and 9.55 per 1000 player-hours for overall, training and match exposures, respectively. Moreover, relative injury ratio for sustaining an injury was 2.6 on average (ranging from 0.88 to 7.07, for tendon and muscle injuries, respectively), indicating significantly higher relative risk ratio in CG than in IG.

Table 2. Results on the effectiveness of the intervention in basketball players.

	Intervention group		Control group		PGROUP	PTIME	PTIME*GROUP
	BDC	POST	BDC	POST			
Anthropometry							
Body height / cm	174.6 [172.7; 176.5]	176.0 [174.1; 178.0]	175.9 [174.1; 177.7]	176.6 [174.8; 178.4]	0.474	<0.001	0.137
Body mass / kg	65.1 [62.5; 67.7]	64.0 [61.4; 66.6] *	64.4 [62.0; 66.8]	65.8 [63.3; 68.3] #	0.756	0.682	<0.001
BMI / kg/m2	21.2 [20.7; 21.8]	20.5 [19.9; 21.1] #	20.5 [19.9; 21.0]	20.8 [20.2; 21.4]	0.542	0.107	<0.001
Fat mass / %	20.5 [19.4; 21.6]	16.4 [15.1; 17.6] #	14.6 [13.5; 15.6]	14.1 [12.9; 15.3]	<0.001	<0.001	<0.001
Y-balance test – normalized per leg length							
Anterior right / %	72.9 [70.4; 75.4]	61.6 [58.9; 64.4]	69.2 [66.9; 71.5]	54.8 [52.2; 57.5]	0.002	<0.001	0.055
Anterior left / %	73.6 [71.3; 75.9]	71.8 [69.3; 74.3]	70.6 [68.4; 72.7]	66.7 [64.2; 69.1]	0.007	<0.001	0.169
Posterior-medial right / %	83.3 [80.9; 85.7]	84.0 [81.5; 86.6]	79.1 [76.9; 81.4]	78.1 [75.5; 80.6]	0.001	0.846	0.275
Posterior-medial left / %	82.6 [80.3; 84.9]	84.8 [82.3; 87.2]	78.0 [75.8; 80.1]	77.7 [75.2; 80.2]	<0.001	0.262	0.138
Posterior-lateral right / %	84.1 [81.6; 86.6]	87.1 [84.4; 89.8]	81.2 [78.8; 83.6]	86.9 [84.2; 89.6]	0.352	<0.001	0.114
Posterior lateral left / %	85.0 [82.5; 87.5]	88.7 [86.1; 91.4]	82.7 [80.3; 85.0]	86.6 [84.0; 89.53]	0.178	<0.001	0.849

Tensiomyography							
VL Td / ms	23.3 [23.0; 23.6]	22.9 [22.6; 23.2] *	22.2 [22.0; 22.5]	22.5 [22.1; 22.9]	<0.001	0.550	0.009
GM Td / ms	22.6 [22.3; 22.9]	22.3 [22.0; 22.7]	22.6 [22.3; 22.8]	23.6 [23.1; 24.0] #	0.005	0.012	<0.001
BF Td / ms	26.1 [25.7; 26.5]	25.9 [25.3; 26.3]	25.4 [25.0; 25.8]	26.3 [25.7; 26.9] $	0.729	0.137	0.005
VL Tc / ms	22.3 [21.8; 22.7]	22.7 [22.2; 23.1]	21.8 [21.4; 22.2]	22.6 [22.1; 23.2]	0.352	<0.001	0.261
GM Tc / ms	22.6 [22.0; 23.2]	22.6 [22.0; 23.2]	22.7 [22.2; 23.3]	25.0 [24.3; 25.8] #	<0.001	<0.001	<0.001
BF Tc / ms	30.0 [28.7; 31.3]	32.6 [31.2; 34.1]	31.3 [30.1; 32.6]	34.5 [32.8; 36.2]	0.066	<0.001	0.592
VL Dm / mm	5.80 [5.55; 6.05]	6.00 [5.72; 6.28]	5.58 [5.34; 5.82]	5.85 [5.54; 6.16]	0.293	0.010	0.695
GM Dm / mm	3.02 [2.86; 3.19]	3.33 [3.14; 3.52]	3.41 [3.25; 3.56]	3.76 [3.56; 3.98]	<0.001	<0.001	0.720
BF Dm / mm	5.61 [5.22; 6.00]	6.65 [6.22; 7.08]	6.04 [5.67; 6.40]	7.09 [6.60; 7.57]	0.101	<0.001	0.957
VL Vr / m/s	0.127 [0.121; 0.132]	0.132 [0.126; 0.138]	0.127 [0.122; 0.132]	0.130 [0.124; 0.137]	0.873	0.043	0.625
GM Vr / m/s	0.067 [0.064; 0.071]	0.074 [0.070; 0.078]	0.075 [0.072; 0.079]	0.077 [0.073; 0.082]	0.017	<0.001	0.069
BF Vr / m/s	0.099 [0.094; 0.105]	0.113 [0.106; 0.119]	0.106 [0.100; 0.111]	0.116 [0.109; 0.123]	0.215	<0.001	0.557
Cognitive ability tests							
sRT / ms	275 [269; 280]	278 [272; 284]	277 [273; 282]	284 [277; 291]	0.195	0.035	0.473
cRT / ms	447 [436; 458]	430 [418; 442]	452 [442; 462]	444 [430; 462]	0.213	0.005	0.272
CORSI / No of items	5.97 [5.75; 6.20]	5.89 [5.62; 6.15]	5.79 [5.59; 6.00]	5.93 [5.64; 6.23]	0.640	0.808	0.313
TMT-A / s	24.2 [23.0; 25.3]	19.3 [18.0; 20.6]	25.1 [24.0; 26.1]	20.9 [19.5; 22.3]	0.103	<0.001	0.422
TMT-B / s	56.4 [52.0; 60.8]	44.3 [39.3; 49.3]	60.3 [56.3; 64.2]	49.1 [43.7; 54.5]	0.137	<0.001	0.785

Decreased from BDC at: * $p < 0.05$; \$ $p < 0.01$; # $p < 0.001$. VL – vastus lateralis; GM – gastrocnemius medialis; BF – biceps femoris; Td – delay time; Tc – contraction time; Dm – radial amplitude; Vr – radial velocity: sRT – simple reaction time; cRT – choice reaction time; CORSI – block-tapping task; TMT-A – trail making test A; TMT-B – trail making test B.

Football: Objective evaluation of the intervention protocol adherence as well as the injury incidence rate cannot be performed due to a low return rate of the required record sheets on the implementation of the intervention in the IG training process and the individual training load of the players of the research group. In the IG, the implementation of NMT in the warm-up was required at least 2 times during the weekly training microcycle, while the CG was asked to implement a usual form of warm-up.

In terms of overall injury prevalence, no differences between IG and CG were observed during the intervention as the values of 50.4% vs. 49.6% of the total number of players were found (IG: 62 injuries vs CG: 56 injuries). Based on a systematic analysis, a higher prevalence of overall sprain/ligament injuries as well as overall muscle injuries were found in CG compared to IG (30.4 % vs. 25.8 %, 30.4 % vs. 19.4 %, respectively). A higher incidence of injuries in CG was observed when assessing the total number of lower body injuries (78.6%) compared to IG (71.0%). In terms of the most injured body parts in football (upper leg - anterior thigh, posterior thigh, hip/groin, ankle, knee), with the exception of knee injuries, similarly, a higher incidence during the intervention period was found in the CG (hip/groin 10.7% vs. 8.1%; thighs 21.4% vs. 12.9%; ankle 17.9% vs. 11.3%). Concerning knee injuries, their incidence was higher in the IG (IG: 19.4% vs. CG: 14.3%) whereas, however, up to 75.0% of injuries in CG were identified as overuse injuries (50.0% for IG). The occurrence of contact injury did not affect the higher incidence of overuse knee injuries identified in IG.

TMG parameters of all three muscles did not differ between IG and CG in time, as there were no significant time*group effects (Table 3). However, we have found significant time effect in GM and BF Td, as well as in Dm parameters, showing increased values at POST. Similarly, there was a time effect with an increase in the recorded values contraction time (Tc) for VL, GM and BF in both IG and CG groups. Furthermore, contraction velocity (Vr) significantly increased in VL, GM and BF at POST in both group IG and CG, too.

No significant changes due to the NMT intervention were found when assessing the interaction of time and group factors in the applied Mixed Linear Model analysis, neither for the characteristics of the Y-balance test, nor for the changes in cognitive abilities.

Table 3. Results on the effectiveness of the intervention in football players.

	Intervention group		Control group		PGROUP	PTIME	PTIME*GROUP
	BDC	POST	BDC	POST			
Anthropometry							
Body height / cm	164.7 [162.4; 167.0]	166.2 [163.7; 168.8]	166.7 [164.2; 169.1]	168.6 [163.6; 169.0]	0.520	0.505	0.271
Body mass / kg	52.0 [50.0; 54.0]	52.9 [51.0; 54.9]	55.7 [53.6; 57.8]	56.2 [54.1; 58.3]	0.017	<0.001	0.093
BMI / kg/m2	19.0 [17.9; 20.1]	18.6 [18.1; 19.1]	19.9 [19.5; 20.4]	19.7 [19.1; 20.2]	<0.001	<0.216	0.777
Fat mass / %	13.2 [12.0; 14.4]	11.3 [10.1; 12.5]	14.7 [13.5; 16.0]	12.9 [11.6; 14.1]	0.078	<0.000	0.985
Y-balance test – normalized per leg length							
Anterior right / %	77.5 [76.3; 78.8]	74.9 [73.5; 76.2]	75.0 [73.7; 76.3]	72.0 [70.6; 73.5]	0.001	<0.001	0.770
Anterior left / %	77.9 [76.7; 79.1]	75.1 [73.8; 76.5]	74.9 [73.6; 76.2]	73.3 [71.8; 74.7]	0.003	<0.001	0.239
Posterior-medial right / %	110.7 [109.1; 112.2]	110.5 [108.8; 112.1]	107.2 [105.6; 108.8]	107.8 [106.0; 109.6]	0.003	0.743	0.519
Posterior-medial left / %	111.0 [109.5; 112.6]	110.8 [109.1; 112.4]	107.7 [106.1; 109.4]	108.3 [106.6; 110.1]	0.007	0.789	0.455
Posterior-lateral right / %	109.6 [107.9; 111.2]	111.4 [109.6; 113.1]	107.4 [105.7; 109.1]	105.6 [103.7; 107.5]	<0.001	0.981	0.006
Posterior lateral left / %	111.6 [110.1; 113.0]	110.3 [108.7; 111.9]	107.7 [106.1; 109.2]	107.6 [105.9; 109.4]	0.001	0.277	0.334
Tensiomyography							
VL Td / ms	21.5 [21.2; 21.8]	21.5 [21.2; 21.8]	21.8 [21.5; 22.1]	21.5 [21.2; 21.9]	0.362	0.290	0.271
GM Td / ms	21.6 [21.3; 22.0]	22.4 [22.1; 22.7]	21.7 [21.4; 22.0]	22.4 [22.0; 22.7]	0.966	<0.001	0.434
BF Td / ms	26.3 [26.1; 27.2]	27.7 [27.2; 28.3]	27.4 [26.9; 28.0]	28.2 [27.52; 28.8]	0.077	<0.001	0.682
VL Tc / ms	21.1 [20.6; 21.6]	21.5 [21.0; 22.1]	21.7 [21.2; 22.2]	22.2 [21.6; 22.8]	0.052	0.011	0.916
GM Tc / ms	22.7 [21.9; 23.5]	25.2 [24.3; 26.1]	22.8 [22.0; 23.6]	26.3 [25.3; 27.2]	0.205	<0.001	0.268

BF Tc / ms	35.6 [34.0; 37.2]	40.3 [38.6; 42.1]	36.7 [35.1; 38.4]	41.5 [39.5; 43.4]	0.239	<0.001	0.985
VL Dm / mm	5.01 [4.77; 5.25]	5.23 [4.98; 5.48]	4,98 [4.73; 5.23]	5.23 [4.96; 5.50]	0.946	0.002	0.811
GM Dm / mm	2.88 [2.72; 3.03]	3.35 [3.18; 3.52]	2.59 [2.43; 2.75]	3.15 [2,97; 3.34]	0.013	<0.001	0.538
BF Dm / mm	8.10 [7.65; 8.55]	8.52 [8.04; 9.00]	7.59 [7.12; 8.07]	7.69 [7.17; 8.22]	0.030	0.122	0.334
VL Vr / m/s	0.117 [0.112; 0.122]	0.121 [0.116; 0.127]	0.114 [0.109; 0.120]	0.120 [0.114; 0.126]	0.644	0.002	0.672
GM Vr / m/s	0.065 [0.062; 0.068]	0.070 [0.067; 0.074]	0.058 [0.055; 0.062]	0.065 [0.061; 0.068]	0.003	<0.001	0.801
BF Vr / m/s	0.132 [0.124; 0.139]	0.126 [0.119; 0.134]	0.120 [0.113; 0.128]	0.115 [0.106; 0.123]	0.025	0.028	0.966
Cognitive ability tests							
sRT / ms	279.1 [274.2; 284.0]	282.9 [277.5; 288.2]	286.1 [280.8; 291.3]	292.2 [286.4; 298.0]	0.014	0.012	0.545
cRT / ms	462.3[450.9; 473.8]	446.0 [433.6; 458.3]	474.0 [461.8; 486.1]	461.8 [448.4; 475.1]	0.079	0.001	0.629
CORSI / No of items	5.6 [5.4; 5.8]	5.8 [5.6; 6.1]	5.6 [5.4; 5.8]	5.8 [5.6; 6.1]	0.733	0.042	0.872
TMT-A / s	28.8 [27.4; 30.1]	23.6 [22.2; 25.1]	30.2 [28.8; 31.6]	23.8 [22.3; 25.4]	0.360	<0.000	0.273
TMT-B / s	63.5 [60.0; 67.0]	50.3 [46.6; 54.1]	64.9 [61.2; 68.6]	51.7 [47.7; 55.8]	0.553	<0.000	0.990

Decreased from BDC at: * p < 0.05; $ p < 0.01; # p < 0.001. VL – vastus lateralis; GM – gastrocnemius medialis; BF – biceps femoris; Td – delay time; Tc – contraction time; Dm – radial amplitude; Vr – radial velocity: sRT – simple reaction time; cRT – choice reaction time; CORSI – block-tapping task; TMT-A – trail making test A; TMT-B – trail making test B.

CONCLUSIONS:

Basketball: We have provided evidence that 15-minute NMT was effective intervention leading to lower relative risk of injuries. Specifically, CG has 2.15 times higher relative injury risk, when compared to the IG, over the entire study duration. Both groups showed improvement in neuromuscular function, as assessed with the Y-balance test, but no differences were observed between both groups. Similar observations were found in most Tensiomyography-derived parameters, particularly for Dm and Tc. However, the Td, in all assessed muscles, was different between groups, with a greater decrease (i.e., positive alterations) in the IG compared to the CG. Adherence to intervention was very high and moderate - achieving 91.1% and 60.2% during intervention and follow-up period, respectively.

Football: As the results show, inclusion of a 15-minute NMT in the warm-up phase at least 2 times in a weekly microcycle leads to injury reduction, specifically in the most injured muscles and sprain/ligaments in young football players. Tensiomyography did not show any significant changes in muscle belly properties due to the NMT intervention performed. A protocol setup that reduced injury appears to be crucial; however, it may not be of sufficient intensity to alter the muscle contractile properties. Similarly, NMT did not have any significant effect on changes in the characteristics of dynamic balance and cognitive functions among football players. Given the lack of adherence data, future research needs to provide more support for the implementation of intervention protocols with direct researcher involvement.

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