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Aquatic neuromuscular training with proprioceptive emphasis: influence on muscle mechanical power and jump height

Treinamento neuromuscular aquático com ênfase proprioceptiva: influência na potência mecânica muscular e na altura de salto

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RESUMO | INTRODUÇÃO: Tarefas motoras treinadas em ambiente aquático parecem potencializar o sistema proprioceptivo. Porém, é necessário investigar o efeito do meio aquático no desempenho neuromuscular de atletas. **OBJETIVO:** Avaliar o efeito de uma intervenção por exercícios neuromusculares funcionais aquáticos, com ênfase no sistema sensorial proprioceptivo, nas variáveis altura do salto e potência muscular, tendo a acuidade proprioceptiva como covariável. **METODOLOGIA:** Amostra composta por 14 homens universitários praticantes de futsal e dividida em grupo controle (GC/n=7) e grupo intervenção (GI/n=7). As variáveis potência mecânica muscular e altura do salto foram avaliadas por meio do teste de salto vertical de 60 segundos. A acuidade proprioceptiva foi avaliada pelo senso de posição articular e pela cinestesia quantificados pelo teste de percepção de movimentos passivos lentos (Tpassivo) e pelo teste de senso de posição articular (Tativo). As variáveis de desfecho foram mensuradas em dois momentos: antes e após a intervenção. A intervenção aquática foi aplicada durante seis semanas com três sessões em cada semana. **RESULTADOS:** Não houve efeito de grupo e nem do momento da avaliação na altura do salto, sendo que o GC alcançou altura de salto de 19,9±0,8 cm em comparação com o GI chegando a altura de 20,3±1,4 cm. Na potência mecânica muscular não houve efeito do momento, mas houve efeito do grupo, em que o GC apresentou potência de 366,2±17,6 W, enquanto GI apresentou 332,0±21,2 W, sendo menor que o GC. Nem o Tativo e nem o Tpassivo influenciaram a altura de salto e a potência mecânica muscular. **CONCLUSÃO:** A intervenção de exercícios neuromusculares aquáticos funcionais, com ênfase na propriocepção não afetou nem a potência muscular nem a altura do salto, este resultado não foi influenciado pela acuidade proprioceptiva.

PALAVRAS-CHAVE: Desempenho atlético. Força muscular. Hidroterapia.

ABSTRACT | INTRODUCTION: Motor skills trained in aquatic environment seem to potentiate the proprioceptive system. However, it is necessary to investigate the effect of the aquatic environment on the neuromuscular performance of athletes. **AIM:** To evaluate the effect of an intervention by functional aquatic neuromuscular exercises, with emphasis on the proprioceptive sensory system, on the variables jump height and muscular power, with proprioceptive acuity as a covariate. **METHODOLOGY:** Sample composed of 14 college men practicing futsal and divided into control group (CG/n=7) and experimental group (EG/n=7). The variables mechanical muscle power and jump height were evaluated using the 60 seconds vertical jump test. Proprioceptive acuity was assessed by the sense of joint position and kinesthesia quantified by the slow passive sensory perception test (Tpassive) and by the joint position sense test (Tactive). The outcome variables were measured in two moments: before and after the intervention. The aquatic intervention was applied for six weeks with three sessions each week. **RESULTS:** There was no group effect nor of the moment at the time of the jump. In the muscular mechanical power, there was no effect of the moment, but there was an effect of the group, with the CG presenting higher values than the EG. Neither Tactive nor Tpassive influenced jump height and muscular mechanical power. **CONCLUSION:** The intervention of functional aquatic neuromuscular exercises with emphasis on proprioception affected neither muscular power nor jump height, this result was not influenced by proprioceptive acuity.

KEYWORDS: Athletic performance. Muscle strength. Hydrotherapy.

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Introduction

Futsal is a sporting modality that requires intense movement, high energy expenditure and the need for a neuromuscular system that is optimized for movements to be executed efficiently, since the abilities related to the athletic gesture depend on the large-scale neuromuscular system[1,2]. Considering the biomechanical substrate of futsal, it is observed the need for frequent changes in direction of movement, being this a mechanism routinely involved in knee and ankle injuries, mainly. Therefore, the search for prevention protocols in sport has been emphasizing[1,3].

Neuromuscular training plays a relevant role, as it enhances athletic performance and reduces the risk of sports injuries. In neuromuscular training with emphasis on proprioception, the exercises focus on the enhancement of motor sensory function, which potentiates afferent information from nerve receptors located in the ligaments, capsules, meniscus, muscles and tendons, and makes the motor response more efficient[4,5].

This training utilizes a combination of physical exercises that are based on functionality, including proprioceptive training, postural stability and strength training, which, by inducing reflex motor responses, improve joint stability. Corroborating, studies show that neuromuscular training is effective in preventing ankle and knee sprains, in addition to reducing mechanical stress in the lower limbs and improving technical skills[4,6]. Therefore, neuromuscular training is also a resource for optimizing sports performance[7]. Specifically in futsal, improvement of the neuromuscular pattern of the lower limbs is essential, since frequent changes in the direction of movement, usually in unipodal support and associated with motor tasks with the contralateral leg, require a great dynamic stabilization of the body structures[5].

The scientific evidence suggests that neuromuscular and proprioceptive training should be implemented in the routine of athletes. Different protocols are described, being able to be practiced in soil or water, and the aquatic environment can promote the benefits in the optimization of variables such as muscular power, speed and height of the jumps[8]. The aquatic environment is described as a facilitator of the neuromuscular functions due to the physical properties of water, since the exercises in water create greater instability due to the decrease of the effects of gravity by immersion and greater moments of turbulence, which makes the motor response more dependent of the proprioceptive system. Other benefits to the aquatic environment are related to the training of the central stabilizers of the trunk, and the potentiation of the dynamic force of the limbs[9–11].

However, the effects of neuromuscular and proprioceptive training in the aquatic environment as a form of prevention in healthy athletes are scarce and remain inconclusive, since other studies mostly describe the prevention and rehabilitation protocols performed in the soil[6,8]. The hypothesis of the present study is that the neuromuscular training adapted to the aquatic environment is able to positively modify the motor, performance and proprioceptive valence of futsal athletes. Therefore, the objective of this study was to evaluate the effect of an intervention by aquatic functional neuromuscular exercises, with emphasis on the proprioceptive sensory system, on the variables height of the jump and muscular power, with proprioceptive acuity as a covariance.

Materials and methods

Participants and ethics of the study

A semi-experimental study with a design model of pre and post intervention measures. The study was approved by the Human Research Ethics Committee of the State University of Western Paraná (UNIOESTE), CAAE: 11457512.4.0000.0107. The volunteers were randomly divided into two groups, being: a control group (CG/n=7), who participated only in the evaluations; and intervention group (IG/n=7), who underwent the intervention procedure and evaluations.

Muscle mechanical power

Variables mechanical muscle power and jump height was evaluated using the vertical jump test of 60 seconds. The athletes jumped on the JumpTest® contact mat (Hidrofit Ltda, Belo Horizonte, Brazil), connected to a laptop computer (Itautec Infoway, Intel Core i3 370M 2.40 GHz, 8.00 GB RAM) with the processing of data from Multisprintfull® software (Hidrofit, Belo Horizonte, Brazil)[12,13]. Each volunteer performed vertical jumps with counter movement from a semi-grained static position, approximately 90° knee flexion, upright trunk, and hands at the waist. Athletes were given verbal incentives to perform jumps at the highest possible pitch throughout the test without removing their hands from the waist[14].

Proprioceptive acuity

Proprioceptive acuity was assessed by the sense of joint position and kinesthesia quantified by the slow passive sensory perception test (Tpassive) and by the articular position sense test (Tactive). The test procedures used in the study by Carvalho et al.[15] were adapted for the use of cinemetry in the determination of articular angle a detailed description in a previous study[16]. For the two-dimensional shooting, a 60Hz video camera (Panasonic NV GS180 3CCD) connected to the VirtualDub software 1.8.8 (build 30091/release).

The patient was placed sitting on a stretcher, with the feet standing, spine erect, blindfolded, and styrofoam markers affixed to the major trochanter of the femur, lateral condyle of the femur and lateral malleolus of the dominant leg (identified as the kicking leg). During the movements, both passive and active, the angular variation was guided by a fleximeter positioned at the ankle. For each test, a familiarization procedure was performed immediately prior to the start of the test. The volunteer received a luminous signal, whose signal was used as reference in the filming, which was triggered when the evaluated considered, by their perception, to be the target angle previously trained in the familiarization. For the determination of the angle between the markers identified in the videos, with the marker of the knee at the origin, Kinovea software was utilized. The trimming frame was the one that in which the light signal appeared.

For the measurement of the Tpassivo, an angular variation of 60° and 30° was established, the first angle for the flexion movement (starting from knee flexion of 15° with reference to the maximum extension) and the second one for the movement of knee extension (starting from 90° flexion). After initiation of recording, the volunteer's leg was moved passively by the evaluator at a steady pace. Immediately upon passing through the target angle, the volunteer turned on the light signal.

To perform the Tactive, the previous positioning was maintained and the volunteer remained blindfolded. Three angular variations were previously defined: 20° extension, 30° flexion and 60° extension. In this test, target angle reproduction was active and the volunteer stopped the test when he realized that he reached the target angle and, at this time, the light signal was triggered.

The value used for the statistical analysis was the difference, in absolute values, between the angle obtained at the moment of familiarization and the angle reproduced by the subject. Such difference was defined as "error value", and represented the mean of the error values of all the variations tested in each test.

Intervention protocol

The neuromuscular intervention with emphasis on the proprioceptive system had a frequency of three weekly sessions, during six weeks, with an average duration of 45 minutes each session. They were performed in the pool of the UNIOESTE Physiotherapy Clinic, with dimensions of 7.80 m wide, 11.80 m long and 1.00 m deep.

A session was held for familiarization and was not counted as treatment. The levels of complexity were increased according to the volunteers' proprioceptive evolution, the evolution was of stable plans, unidirectional planes, response predictability, unstable planes, multidirectional planes and unpredictable responses.

Each exercise session was organized in three basic conditions: static phase, with pelvic stabilization exercises; dynamic phase, in which volunteers were required to maintain pelvic stabilization in a range of situations that challenged their center of gravity; functional phase, with activities that challenged the postural control composed by conditions that requested the monopodal support, bipodal, imbalances provoked by the therapist or by the exercise, variations of intensity of the exercises and the stability of the support; vision deprivation; displacements in all directions; acceleration and deceleration and exercises in closed and open kinetic chains, as well as muscle coordination exercises[17]. Among the proprioceptive exercises, activities were performed with ball in na aquatic environment, to reproduce the sport gesture and the motor fixation of the activity.

Statistical analysis

For statistical analysis, the SPSS 20 program was used. The accepted level of significance was 5% (α=0.05). Generalized Linear Mixed Effects (GLMM) models with Bonferroni test were used as post-hoc to find the statistical differences in order to find the principal effects of the group and the moment of collection. The unpaired t-test was utilized to compare if there was difference between the groups in the initial evaluation (pre-moment) for the variables analyzed.

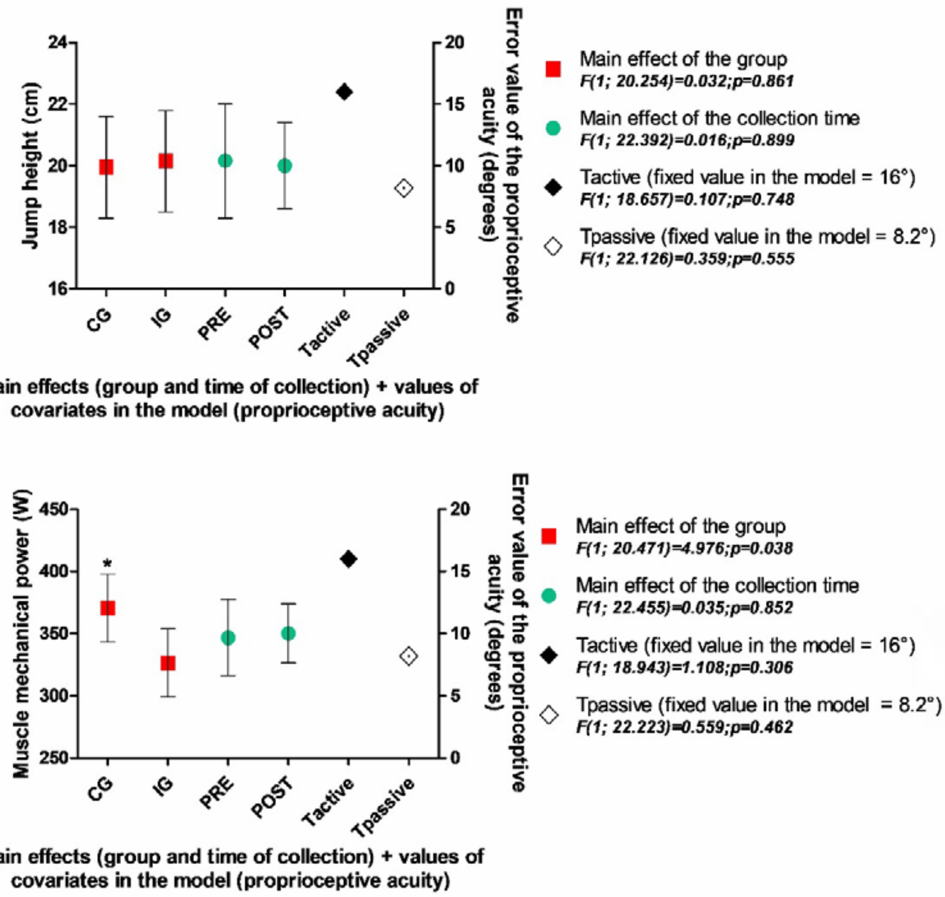
Results

The sample consisted of 14 college men aged 18 to 30 years, recreational futsal practitioners and college tournament participants, with mean age of 21.0 ± 1.7 years, body mass of 72.2 ± 8.0 kg and height of 1.77 ± 5.78 m. For this sample size, relative to jump height, and minimum difference of 1.5, standard deviation of 1.2, the power of the test was 80%.

The groups were not different at the time of pre-collection for any of the analyzed variables: jump height (CG=19.9±0.8 cm / IG=20.3±1.4 cm / T(12)=0.2547, p=0.8033), mechanical muscle power (CG=366.2±17.6 W / IG=332.0±21.2 W / T(12)=1.858, p=0.0879), value (CG=12.5±1.9 degrees / IG=17.1±1.8 degrees / T(12)=1.703, p=0.11142), error value for the Tpassive (CG=5.4±1.4 degrees / IG=6.4±1.5 degrees / T(12)=0.4746, p=0.6436).

There was not any group effect or the time of the evaluation at the time of the jump. Of muscle mechanical power, there was an effect of the group, but not at the moment of collection. Neither the sense of joint position (Tactive) nor the perception of slow passive movements (Tpassive) influenced jump height and muscular mechanical power. The results are presented in figure 1.

Figure 1. Descriptive statistics, with mean and 95% confidence interval, and inferential to verify the group effect (control groups - CG and intervention - IG) and moment (preintervention and postintervention moments) for the variables jump height and muscular power, with the tests of the sense of joint position (Tactive) of the perception of slow passive movements (Tpassive) as covariables



Discussion

The objective of this study was to evaluate the effect of the intervention by functional aquatic neuromuscular exercises, with emphasis on proprioception, on the variables jump height and muscular mechanical power, with proprioceptive acuity as a covariate. The hypothesis of the present study about the effect of the intervention with neuromuscular exercises adapted to the aquatic environment was not confirmed, since there were no positive changes in the height of the heel after the intervention and only the CG presented an improvement of the mechanical muscular power, without the acuity proprioceptive influence.

It is known that proprioception occurs as a mechanism between the central and peripheral nervous system and is involved in the actions of the muscle spindles and other receptors present in the joints[18]. Although movements in the liquid medium generate turbulence and consequently increase resistance to movement, and consequently cause overload capable of inducing adaptation in the neuromuscular system[19], the overload from the proposed intervention may not have been sufficient to generate adaptations in the neuromuscular and proprioceptive systems.

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In a study by Jurado-Lavanant et al.[20], when comparing the effects of plyometric exercises in water and soil, observed that the group that performed the exercises in the soil presented greater gains and better performance during the jump. In order for the adaptation process to take place, it is necessary that the load be enough to potentiate muscular strength and physical performance[20]. Successful training is one that includes controlled loads in order to promote physiological and functional response[1,21]. However, in the water, the control of the loads was more difficult, because the magnitude of the turbulence is proportional to the speed of execution of the movement, which makes complex the management of the loads only by the perception of effort of the volunteer.

According to Torres-Ronda and Alcázar[21], water offers resistance to training due to its density and viscosity properties, but although the physical properties of water may favor resistance, the aquatic environment is not the training for futsal. This undermines the principle of specificity that it advocates for specific training that contemplates the gestures practiced by the athletes, being a limitation of this study the lack of a group trained in solo. In the study by Mineiro et al.[22] a plyometric aquatic training program was conducted for young futsal players with static and dynamic jumping exercises. The authors observed improvement of muscular power, but this manifestation of force was not transferred to the sporting gesture in futsal.

It was observed from the results of the present study that there was a group effect, with the CG presenting higher levels of muscular mechanical power than the GI. This result may have been a consequence of the water temperature. Studies indicate that immersion in hot water reduces sports performance[21,23], because the heat changes the sensory system, reduces the sensitivity of nerve endings and the activation of muscle spindles[24,25] causing relaxation in the muscles and impairing the muscle's ability to generate power. Although the water remained warm during the interventions, around 33 degrees, daily temperature control was not performed, this being another limitation of the study.

Conclusion

Intervention of functional aquatic neuromuscular exercises with emphasis on proprioception did not affect either muscular power or jump height and this result was not influenced by proprioceptive acuity.

Author contributions

Wutzke MLS participated in the collection and analysis of data, and writing the scientific text; Bertolini GRF participated in the design of the study, data analysis and review of the manuscript; De Carvalho AR participated in the conception of the study, data collection and analysis, and the final revision of the manuscript.

Conflicts of interest

No financial, legal or political conflict involving third parties (government, business and private foundations, etc.) was declared for any aspect of the work submitted (including but not limited to grants and funding, advisory board, study design, manuscript preparation , statistical analysis, etc.).

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