STUDIA UBB EDUCATIO ARTIS GYMN., LX, 2, 2015, pp. 57 - 66
(RECOMMENDED CITATION)

ISOTONIC VS. ISOKINETIC AQUATIC TRAINING: IMPROVEMENT OF THE NEUROMUSCULAR CONTROL OF THE LOWER LIMBS IN HEALTHY AND UNTRAINED FEMALES

JUDIT-KLÁRA MARIAN[1]*, NICOLAE HORAȚIU POP[2]

ABSTRACT. Introduction. The most important advantage of isotonic training is that there is no need for the human body to perform adjusting processes during execution: hence the accuracy of movement is less perturbed. Recent studies have shown balance and stability improvements after isokinetic training performed either by dynamometer or aquatic programs. **Purposes.** Our primary goal was to determine what the difference is between concentric isotonic and aquatic isokinetic training programs and how much these types of trainings affect the neuromuscular control of the lower limbs. Improving the subjects' fitness level and their motivation to exercise regularly was the secondary goal of this study. **Methods.** Ten young, healthy and untrained female adults participated in this study. The subjects were divided into two groups: aquatic (n=5) and fitness (n=5). Before and after training the subjects' lower limb neuromuscular control was assessed by the Shark Skill test (SST). The aquatic group (AG) trained in a 1.5 meter deep swimming pool, while the fitness group (FG) trained at a gym, using weights. The subjects of both groups trained for six weeks, three times per week. **Results.** The final SST proved bilateral amelioration of the neuromuscular control for AG, while FG improved unilaterally. The dominant limb improved more than the non-dominant one. The length of the lower limb negatively influenced the initial SST scores, especially at the FG. The tallest subjects of the AG developed the most their neuromuscular control. **Conclusions.** Post-experimental neuromuscular control improved in both groups. We did not find evidence that a group improved more than the other. The length of the lower limb negatively influences the neuromuscular control, but it can be developed due to regular training sessions of the lower extremity. The subjects' fitness level and motivation for regular training increased.

Key words: *isotonic, isokinetic, neuromuscular control, lower limb*

[1] *Kinetoterapeut voluntar la Centrul de zi pentru persoane vârstnice, Aleșd*
[2] *Universitatea „Babeș-Bolyai" Cluj-Napoca, Facultatea de Educație Fizică și Sport*
**Corresponding Author: m_judith17@yahoo.com*

REZUMAT. ***Compararea antrenamentului izotonic cu antrenamentul izokinetic acvatic: îmbunătățirea controlului neuromuscular al membrelor inferioare la femei sănătoase și neantrenate.*** **Introducere.** Principalul avantaj impus de antrenamentul izotonic se manifestă prin absența capacității de adaptare a organismului pe parcursul exersării, facilitând o execuție mai precisă, lipsită de factori perturbători. Studii recente dovedesc ameliorarea echilibrului, în consecinţă şi a stabilităţii, în urma antrenamentelor izokinetice fie pe dispozitiv, fie în mediul acvatic. **Obiective.** Depistarea diferenței dintre efectele antrenamentului izokinetic acvatic și antrenamentului izotonic concentric asupra controlului neuromuscular al membrelor inferioare a reprezentat obiectivul primordial. Secundar, am urmărit creșterea nivelului de fitness al subiecților și dezvolarea motivației acestora de a efectua exercițiu fizic. **Metode.** Zece subiecţi tineri, sănătoşi, neantrenaţi şi de sex feminin au participat la acest experiment. Aceștia au fost evaluați prin testul Shark (SST) și împărţiţi în două grupe experimentale: lotul bazin (n=5) și lotul fitness (n=5). Lotul bazin (AG) s-a antrenat la o adâncime a apei de 1.5 metri, iar lotul fitness (FG) a efectuat exerciții într-o sală de fitness cu ajutorul aparatelor. Ambele grupe s-au antrenat cu o frecvență de trei ședințe pe săptămână, pe durata a șase săptămâni. **Rezultate.** Conform SST, AG a demonstrat îmbunătățiri bilaterale ale controlului neuromuscular, iar FG a evoluat doar unilateral. S-au observat ameliorări din perspectiva membrului dominant. Lungimea membrelor inferioare a influențat negativ scorul inițial al SST, vizibil în special la FG. Controlul neuromuscular al subiecților cu membre inferioare mai lungi din AG s-a dezvoltat în cea mai mare măsură. **Concluzii.** Controlul neuromuscular post-experimental a fost îmbunătățit în cazul ambelor loturi. Diferența dintre efectele celor două tipuri de antrenament este nesemnificativă. Lungimea membrelor inferioare influențează negativ controlul neuromuscular, însă acesta se poate îmbunătăți prin efectuarea regulată a unor exerciții fizice analitice adresate trenului inferior al corpului. S-a atins obiectivul creșterii nivelului de fitness și obținerea aspirației de a efectua exercițiu fizic în mod regulat.

Cuvinte cheie: *izotonic, izokinetic, control neuromuscular, membre inferioare*

Introduction

The difference between the effects produced by isotonic and isokinetic trainings have been studied for the last decades. Some studies demonstrated that besides strength and endurance enhancements, other effects may appear as well.

The majority of training programs are based on isotonic muscular activity, using weights. The most important advantage of isotonic training is that there is no need for the human body to perform adjusting processes during execution: hence the accuracy of movement is less perturbed. Physical activity performed in water is less common and it is completely different than working out using weights. The aquatic environment provides a specific exercising condition due to the reduced influence of gravity and the other properties of water: viscosity, buoyancy and hydrostatic pressure (Pop, 2013). This way, it is much harder to master motor control. It has been shown that the aquatic environment stimulates deep and cutaneous nerve endings (Salvi, Quarenghi & Quarenghi, 2006; Katsura et.al, 2010) as well as the feed-forward and feedback mechanisms in order to maintain correct posture (Roth et.al, 2006; Sarshin et.al, 2012). Other recent studies have claimed balance and stability improvements in healthy adults after isokinetic training performed either on isokinetic dynamometer or in water (Jalili, 2011; Kim et.al, 2011; Sarshin et.al, 2012). Condromalacia patellae (Yildiz et.al, 2003) and functional ankle instability (Sekir et.al, 2007) in recreational athletes were also ameliorated after isokinetic training; the researchers assumed proprioception and balance development. Since proprioception, stability, feed-forward and feedback mechanisms are component parts of the neuromuscular control, these results suggest that regular isokinetic muscular activity improves the neuromuscular control to a larger extent than the isotonic training would do.

Analyzing the two muscular activity types, comparative investigations were conducted by Avelar et.al, 2010, and Kieffer et.al, 2012. Each of them studied healthy elderly subjects. Avelar et.al found static and dynamic balance improvements in both isotonic and isokinetic conditions. Kieffer et.al proved enhanced functional abilities in the aquatic isokinetic group. According to Golik-Peric et.al, 2011, an isokinetic protocol performed on a dynamometer confirmed production of more significant effects than the isotonic exercise program, when aiming to reduce asymmetry between quadriceps and hamstring muscles.

On the contrary, several other researches failed to demonstrate any positive change in motor control after isotonic or isokinetic exercise programs. Wojtoys et.al, 1996, applied strength training programs on the lower limbs in three different conditions: isotonic, isokinetic and agility. Examining the neuromuscular adaptations accomplished by these programs, they noticed upgrade of muscle reaction time only in the agility group. The isotonic and isokinetic groups did not reveal any results. Likewise, Remaud et.al, 2010, studied the neuromuscular adaptations of the quadriceps muscles by comparing the outcomes of isotonic versus isokinetic training programs. The results of their research evidenced increase of muscular strength without any significant difference between the two training groups.

Purposes

The purpose of this study was to compare the effects produced by isotonic versus isokinetic muscular activity. Our primary goal was to determine what the difference is between concentric isotonic and aquatic isokinetic training programs and how much these types of trainings affect the neuromuscular control of the lower limbs. Improving the subjects' fitness level and their motivation to exercise regularly was the secondary goal of this study.

Methods

Ten young, healthy and untrained female adults were recruited in this study as volunteers, giving informed consent about their agreement to participate. The subjects were freshmen students at the Faculty of Letters, belonging to the „Babeș – Bolyai" University of Cluj-Napoca. None of them suffered injuries or surgical interventions of the lower limbs. According to the subjects' preferences, they were divided into two experimental groups: aquatic (n=5) and fitness (n=5).

Prior to applying the training programs, the subjects filled in a questionnaire giving information about their physical activity status, based on three parameters: intensity, duration and frequency. Under this assessment, the subjects were classified as sedentary or relative sedentary. Following this, height, weight and the length of the lower limbs were determined. Stating the dominant leg was achieved by questioning the subjects about which one of the legs they would use for kicking a ball. The neuromuscular control of the lower limbs was assessed by the Shark Skill test (SST).

The aquatic group trained in a swimming pool, belonging to the "Universitas" Swimming Pool in Cluj-Napoca. The depth of the water was of 1.5 meters and its temperature was of 33°C. Attending the gym of the Faculty of Sports and Physical Education, the fitness group practiced using weights. Both experimental groups trained for six weeks, three times per week. Each training session lasted approximately 45 minutes, starting with a 10 minute warm-up, followed by the exercising protocol and a 5 minute stretching for cool-down. The training protocols included ankle, knee and hip joint drills.

After six weeks of practice, a final assessment was completed. A second weight measurement was taken along with repeating the SST and filling in an anonymous questionnaire in consideration of the subjects' fitness level and their motivation for regular training.

Results

According to the subjects' answers, related to their initial fitness level, two out of five subjects belonging to aquatic group (AG) were leading a sedentary lifestyle, while the other three were relatively sedentary. In the fitness group (FG) all subjects admitted to be sedentary.

With respect to the dominant leg test, all subjects of FG affirmed that their right legs were the dominant ones. One out of five subjects in AG would kick a ball with the left foot; the other four would use the right one.

Table 1. Mean and SD values of weight and SST

Parameters	**Aquatic Group**		**Fitness Group**	
	Pre-training	Post-training	Pre-training	Post-training
W	79.6 ± 16.34	81.1 ± 16.31	57.8 ± 11.21	58.1 ± 10.44
RLL	12 ± 2.89	10.56 ± 2.7	11.88 ± 2.71	10.44 ± 1.14
LLL	13.16 ± 4.95	11.02 ± 2.57	14.12 ± 2.66	10.98 ± 1.85
DLL	11.6 ± 2.52	10.62 ± 2.73	-	-
NdLL	13.56 ± 4.99	10.96 ± 2.55	-	-

W, weight; RLL, right lower limb; LLL, left lower limb; DLL, dominant lower limb; NdLL, non-dominant lower limb.

Using the Paired Samples t-test pre- and post-training weight and SST scores were statistically analyzed at a $p<0.10$ significance level. The mean and the standard deviations (SD) for each measurement are represented in Table 1. The high values of SD in case of weight indicate major differences among the subjects, ranging from low values to high values. Neither the AG ($p=0.224$), nor the FG lost weight ($p=0.345$). Moreover, there is a slight increase in both groups, which probably is a result of muscle gain.

After the intervention the SST scores for AG diminished in RLL ($p=0.047$) and LLL as well ($p=0.064$). The SD for LLL reduced considerably, increasing the homogeneity of the group, meaning that divergence among the motor control level of the subjects tended to gather to a common basis. FG claimed marked results only at LLL ($p=0.024$). Although a tight decrease of the SST scores for RLL exists, these results are not statistically significant ($p=0.123$).

In most of the cases the neuromuscular control is asymmetrical. There is a tendency to use the dominant limb more frequently; that is why inequalities are expected to be met between the neuromuscular control of dominant and the non-dominant limb. Taking into consideration this aspect, pre- and post-training SST scores were analyzed from this perspective, too. Statistical interpretation of the data revealed a true improvement for DLL of AG ($p=0.053$), while NdLL failed to progress ($p=0.038$). The SD value of NdLL diminished in the same manner it did in case of LLL. This decline was foreseeable, given that LLL was the non-dominant limb in 80% of the subjects of this group. Since every subject of the FG claimed RLL to be the dominant one, examination corresponds to the one described above at RLL and LLL section.

Confronting the results of the two experimental groups, we conducted data analysis employing the Independent Samples t-test. Similarly to former analysis, calculations were made at $p<0.10$ significance level. Exactly as we predicted, there was no difference regarding the initial SST scores of the groups for either lower limbs as Table 2 shows ($p=0.473$ for RLL; $p=0.356$ for LLL). Surprisingly, apart from the SD value, no other distinguishing progress was discovered between AG and FG ($p=0.464$ for RLL; $p=0.49$ for LLL), presented in Table 3. The SD value reduced repeatedly, approaching the subjects' control level to a common basis.

Table 2. Initial mean and SD values of SST

	AG	FG
RLL	12 ± 2.89	11.8 ± 2.71
LLL	13.16 ± 4.95	14.12 ± 2.66

AG, aquatic group; FG, fitness group; RLL, right lower limb; LLL, left lower limb

Table 3. Final mean and SD values of SST

	AG	FG
RLL	10.56 ± 2.7	10.44 ± 1.14
LLL	11.02 ± 2.57	10.98 ± 1.85

AG, aquatic group; FG, fitness group; RLL, right lower limb; LLL, left lower limb

A possible correlation between the length of the lower limbs and the SST scores was examined. We used the Pearson's correlation calculated by the Microsoft Office Excel 2010 programme. For AG the initial SST scores were in a slight positive interaction with the lenght of lower limbs. Pearson's coefficients gave negative values when confronting final SST scores with the lower extremities lenght. The essence of these results is that, former to the training sessions, the taller subjects of AG performed poorer than the smaller ones, which turned the other way around after the experiment, especially for RLL. The correlation coefficients computed for FG presented positive values at both limbs prior and post intervention as well. The initial scores were much superior to the final ones, expressing early negative influence of the length of the lower limb on the neuromuscular control, which modified post experiment. These results are more emphasized in case of RLL.

Table 4. Correlation coefficients

Pearson's correlation		Initial	Final
AG	RLL	0.042	– 0.242
	LLL	0.002	– 0.074
FG	RLL	0.770	0.203
	LLL	0.563	0.387

AG, aquatic group; FG, fitness group; RLL, right lower limb; LLL, left lower limb

Fitness level improvement was noticed by every subject participating in this study. Regarding their motivation to continue regular phisical activities, nine out of ten claimed to remain active and one preferred leading the same lifestyle she was used to.

Discussion

The effects produced by a concentric isotonic versus an aquatic isokinetic training were studied in relationship with the neuromuscular control of the lower limbs. After 18 training sessions organized in six weeks, differences and similarities between the two experimental groups were found as well.

Weight changes produced by the training programmes are not statistically significant. The existing slight gain is probably due to muscular hypertrophy, as a result of regular physical activity.

Bilateral amelioration of the neuromuscular control was established for the aquatic group. The fitness group improved unilaterally, developing only the left lower extremity's agility. One possible explanation for this might be an early satisfying motor control of the right leg, which was the dominant one for all subjects of the fitness group. Therefore, the left lower extremity progressed in a greater extent, also validated statistically.

Significant statistical evidence was found from the dominant leg's angle, too. Initially, the homogeneity of the aquatic group was small, but post-interventional analysis showed a positive increase of this parameter. The revealing improvement hints at reaching to a common control level of the subjects. Since all participants of the fitness group claimed the right leg to be the dominant one, this perspective coincides with an already existing analysis.

Former to the experiment, we presumed that divergences will be found between the outcomes of the two training types. However, no statistically significant dissimilarity was collected. The conclusive development of both of the experimental groups certainly ows to the early sedentary lifestyle of the subjects.

Apparently, poor fitness level can be developed easily with any kind of regular physical activity, may that be concentric isotonic or aquatic isokinetic training. Perhaps studying phyisically more active people, some obvious discrepancies would have been observed. Besides, conducting a long-term research and using a larger number of participants might demonstrate other effects on the neuromuscular control of the lower limbs.

Considering that the center of gravity during orthostatic position is situated at the second lumbar vertebrae, the longer the lower limbs are, the harder it is to maintain balance. Gribble & Hertel, 2003, examined the role of foot type, height, leg length and range of motion while performing the Star Excursion Balance Test and found that height and leg length interact with balance. Denyer, 2013, confirmed that foot structure plays an important role in neuromuscular control, too. Thus, we considered examining the neuromuscular control with respect to the lower limbs' lengths. As it was expected, length negatively influenced the initial SST scores for both groups, especially for the right legs of the fitness group. We suppose that a phyisiolgical asymmetry is present for everyone, as a result of having a dominant and a non-dominant side of the body. As a child grows into an adult, their dominant leg becomes specialized in making more precise and controlled movement patterns, like kicking a ball for example. At the same time, the other leg needs to bear the whole bodyweight, being trained to stabilize the body while the movement is being accomplished. Therefore, the SST scores were obviously higher for the less controlled leg, which was the left one for each subject of the fitness group. After the experiment, disparity between the two limbs reduced, similarly as it happened in a study organized by Golik-Peric et.al, 2011.

Surprisingly, the taller subjects of the aquatic group developped their neuromuscular control to a greater degree than the shorter ones. The length of the lower limb as well as the orthostatic posture maintained during the execises could have had a positive effect. The longer the limbs were, the greater the amplitude of motion is and the larger the surface is, that can be stimulated by water. Consequently, taller subjects might have percieved every exercise more intensely than the shorter subjects did. As we do not have evidence for this theory, it could be studied in a future research.

Conclusions

Both concentric isotonic and aquatic isokinetic training programs improve the neuromuscular control of the lower limbs. Post-experimental SST scores validate development in both groups, without any significant difference between them. The lack of discrepancy might be caused by the short period of the research, the reduced number of participants or the poor fitness level of the subjects. Ameliorations are present from the dominant-non-dominant point of view, too. The length of the lower limb negatively influences the neuromuscular control, but it can be developed due to regular training sessions of the lower limbs. This improvement was particularly noticed at the taller subjects of the aquatic group. The subjects' fitness level and motivation for regular training increased.

REFERENCES

Avelar, N.C.P. et.al (2010). Effectiveness of aquatic and non-aquatic lower limb muscles endurance training in the static and dynamic balance of elderly people. *Journal of Revista Brasileira de Fisioterapia*, 14(3), 229-236;

Denyer, J. (2013). *The Effects of Foot Structure and Athletic Taping on Lower Limb Biomechanics (Doctoral dissertation).* Retrieved from University of Hertfordshire. (*http://uhra.herts.ac.uk/handle/2299/10400*);

Golik-Peric, D. et.al (2011). Short-Term Isokinetic Training Versus Isotonic Training: Effects on Asymmetry in Strength of Thigh Muscles. *Journal of Human Kinetics,* 30, 29-35;

Gribble, P.A. & Hertel, J. (2003). *Considerations for Normalizing Measures of the Excursion Balance Test [Abstract]*. Measurement in Phyisical Education and Exercise Science, 7(2), 89-100. Retrieved from *http://www.udel.edu/bioms/seminararchives/05_06/Gribble.pdf*;

Jalili, M. (2011). Changes in balance and neuromuscular performance following Whole body vibration and aquatic balance training in elderly subjects. Journal of Annals of Biological Research, 2(6), 489-495;

Katsura, Y. et.al (2010). Effects of aquatic exercise training using water-resistence equipment in elderly. *Journal of European Journal of Applied Physiology*, 108, 957-964;

Kieffer, H.S. et.al (2012). The Effects of a Short-Term Novel Aquatic Exercise Program on Functional Strength and Performance of Older Adults. *International Journal of Exercise Science*, 5(4), 321-333;

Kim, K., Cha, Y.J. & Fell, D.W. (2011). The effect of contralateral training: Influence of unilateral isokinetic exercise on one-legged standing balance of the contralateral lower extremity in adults. *Journal of Gait & Posture*, 34, 103-106;

Pop, N.H. (2013). Înotul: competiție și utilitate. Cluj-Napoca: Risoprint.

Remaud, A., Cornu, C. & Guével, A. (2010). Neuromuscular adaptations to 8-weeks strength training: isotonic versus isokinetic mode. *Journal of European Journal of Applied Physiology*, 108, 59-69;

Roth, A.E. et.al (2006). Comparisons of Static and Dynamic Balance Following Training in Aquatic and Land Environments. *Journal of Sport Rehabilitation,* 15, 299-311;

Salvi, G., Quarenghi, A. & Quarenghi, P. (2006). Rehabilitation in water: A practical guide. In León-Carrión, J., R.H. von Wild, K. & Zitnay, G.A. (Ed.), *Brain Injury Treatment: Theories and Practices* (pp.250-252). New-York: Taylor & Francis;

Sarshin, A. et.al (2012). The effect of ten weeks strength training and aquatic balance training on dynamic balance in inactive elder males. *Journal of Annals of Biological Research*, 3(2), 850-857;

Sekir, U. et.al (2007). Effect of isokinetic training on strength, functionality and proprioception in athletes with functional ankle instability. Journal of Knee Surgery, Sports Traumatology, Arthroscopy, 15, 654-664;

Wojtys, E.M. et.al, (1996). Neuromuscular Adaptations in Isokinetic, Isotonic and Agility Training Programs. *American Journal of Sports Medicine*, 24(2), 187-192;

Yildiz, Y. et.al (2003). Relation between isokinetic muscle strength and functional capacity in recreational athletes with condromalacia patellae. *Journal of British Journal of Sports and Medicine*, 37, 475-479.