144 - THE INFLUENCE OF THE STEP HEIGHT AND THE MUSICAL CADENCE ON THE GROUND REACTION FORCE IN TWO MOVEMENTS OF STEP TRAINING

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INTRODUCTION

The *Step Training* was one of the novelties in the 90s, arising from the adaptation of the Swedish bench by the Professor Gin Miller, whom after having undergone a knee surgery, the physicians recommended her to go up and down a bench for rehabilitation of the suffered injury (Nascimento e Nogueira, 1993). With this fact, it was created a new work proposal; substituting the traditional aerobics gymnastics indicated for supposedly causing innumerable injuries in its practitioners due to the raised impact suffered by the joints during the movements. The *Step Training* was distinguished for guaranteeing an activity of high intensity; however with low impact on the joints, thus, devoting itself as aerobics gymnastics of low impact.

According to Jucá (1993) step training is a training program that consists of going up and down form an adjustable platform, using music for marking the rhythm. The platform height, the speed of the music cadence and the diversity in the selection and combination of steps types (choreography) are elements used to evolve in the training and also determinative factors of the intensity and motivation of the class. Since its sprouting this modality has been suffering changes and adapting its choreographies and the speed of the movements execution to attend the practitioners expectations. Currently, the classes are given with cadences that determine the speed of the movement execution, varying from 132 to 160 beatings per minute (bpm) with more complex steps each time. The simple basic step, the subject in front of the "step" goes up the right foot, goes up the left foot, returning backwards going down the right foot and after the left foot, currently this is part only of the beginning of the choreography being used to evolve in it. The same happens with the simple step of knees rising, that consists on going up the right foot, keeping it held on the "step", after raising up the left knee, returning with the left foot to the floor and right after that going down the right foot. These two movements are called, respectively, of steps with simple leadership (it does not change the command leg) and step of alternating leadership (it changes the command leg).

The platform height with the passing of the years, in consequence of class high intensity and by the complexity of the choreography used by the teachers, went from 30cm to 10 and 20 cm. From its beginning to nowadays, the execution speed went from speed of 120 bpm to 160bpm. In this aspect it becomes indispensable the knowledge of the load that the locomotor apparatus is being submerged to obtain the indicator of the level of load that the body is exposed in this kind of activity. This load can be analyzed through the extreme ground reaction force (GRF), which is, by the force of the reaction produced by the horizontal surface of support. The GRF is one of the strengths that act on the locomotor system and that have more influence on the load that the same expose itself (Nigg e Herzog, 1994). It can be decomposed by three components: vertical, antero-posterior and medium-lateral. In this study it was only analyzed the vertical component of GRF because the other two components were influenced directly by the level of movement control (Wieczorek, Duarte e Amadio, 1997).

Many studies analyzing the GRF have already been made, however they had withheld to the cadence of up to 140 bpm and, moreover, to the use of the basic step in the majority of the studies found in the bibliography. Based on the previews statements and on the necessity of new researches that approached higher movement speeds, this study had the objective of evaluating the implication of different music cadence (136, 140, 144 e 152 bpm) on the platform heights of 10 and 20 cm on a vertical component of GRF in the basic step and simple knee rising in the descending phase of the movement.

METHODOLOGY

In order to obtain the dynamometrical variables it was used two platforms of extensometer forces developed by ROESLER (1997) with sensibility of 2N and capacity for measuring the strengths and movements on the three coordinates axles. The system acquisition capacity is of 60.000 points/second, being that the same presents errors inferior to 1%, seen its constant gauging to each collection. The loads that are applied on the force platform are converted to electric tensions that are amplified and converted through an analogical/digital converter. These signals storage and processing had been done through the System of Data Acquisition (SAD 32). Both the platforms had been fixed, one to the ground level and another one on the heights of 10 and 20 cm, representing the "step", through the overlapping of wood boxes constructed to such end. For the speed control it was used CD's recorded on the speeds to be tested and in order to gauge the anthropometric measures it was used a metallic tape measure. The data collection was carried out in the Laboratory of Aquatic Biomechanics of the CEFID/UDESC.

The study group was composed by 5 teacher of the modality of *Step Training* of both sex (3 men and 2 women) with average age of 25 ± 3,08 years and inferior members length of 83 ± 3,29 cm. The subjects have carried out a total of 12 cycles of basic step and 12 cycles of simple alternating knee step on heights of 10 and 20 cm, and the speeds of 136, 140, 144 and 152 bpm with the leg leadership chosen by the subjects themselves. The data collection occurred in the following way: The citizen went up on the platform for acquisition of the corporal weight (CW); after that, he/she went down the platform and started a march on the place in order to find the rhythm of music; after the subject started the execution of 12 cycles of the basic step and soon after that, without any interval, the execution of 12 cycles of the simple knee alternating step in each one of the proposed speeds. Between each speed exchange there was an interval and the subject waited the command to start the march on the floor and the movements executions. The collection started with the platform adjusted to 10 cm high, with the subject executing the basic and simple alternating knee step with the speed of 136 bpm and after the interval with the speeds of 140, 144 and 152 bpm. After a bigger interval the superior platform was adjusted to 20 cm high and the same previous procedure was carried out.

After the data collection processing, these were normalized by the corporal weight of each subject. Only the results of the inferior platform were analyzed, therefore the largest values of pressure and force are verified in the descending phase of the movement, that is, on the inferior platform (Panda, 2001; Ávila, Souza e Nascimento 2003; Rieger et al, 2001; Wieczorek, Duarte e Amadio, 1997). This can be explained by the action of gravity force in favor of the movement. It was analyzed 8 cycles of each step; being rejected the first two and the last two cycles of basic and simple alternating knee step. This was done by the fact that it can characterize as the beginning and the end of each movement, and thus, avoiding the effects of the acceleration process that gives originates the movement and that the process of deceleration by the end of the movement could intervene in the motor sample standard. The statistics analysis was carried out using the Statistics Software version 6.0. The comparison between the values of GRF in the 4 speeds of the present study had been carried out based on the result of the Variance Analysis test ANOVA One Way. For the comparisons between the heights of the platform (10 and 20 cm) it was used the Test "t" of *Student* for dependent samples.

RESULTS AND DISCUSSION

The data of GRF illustrated in tables below were normalized by the corporal weight (CW) of the subject for better understanding of the results. In table 1 is presented the results obtained in the basic step in the four cadences and the two heights of "step". Analyzing the vertical lines of table 1 we can compare the influence of the execution speed on the GRF at the heights of 10 and 20 cm. The found values are not statically significant to $p < 0,05$. At the height of 10 cm the smaller value found was of 1,43 CW (136 bpm), 1,5 CW (140 bpm), 1.51 CW (144 bpm) and 1.61 CW (152 bpm). The results are not in accordance with the studies carried out by Rieger et al (2001) that also had compared the effect of the increase cadence and "step" height on the GRF in the basic step. At the height of 10 cm they found a reduction of the value of GRF in the transition from 132 to 136 bpm, finding an increase only in the passage of 136 to 140 bpm. At the height of 20 cm the smaller value of the GRF found was of 1,68 CW (136), 1,73 CW (140), 1,74 CW (144) and 1,80 WC (152). As in height of 10 cm, the found values did not statically differed to $p < 0,05$. These results again oppose the study done by Rieger et al (2001), in which the values had reduced with the increase of all speeds (132, 136 e 140 bpm) at the height of 20cm.

Yet, in table 1, we can compare (horizontal lines) the influence of the platform height on GRF when analyzed on the same speed. Analyzing the difference of GRF between the heights 10 and 20 cm it is found larger values accordant to the increase of speed movement, defined by the music rhythm. It was found statistically significant differences between all the analyzed cadences, except in the speed of 152 bpm ($p > 0,05$) in which the difference between using one "step" of 10 or 20 cm was not significant. In all the other cadences, the increase of the height of "step" provoked a statistically significant increase in the GRF: 136 bpm ($p = 0,0378$), 140 bpm ($p = 0,0175$) and 144 bpm ($p = 0,0323$).

Table 1: Average and standard deviation of GRF in the two platform heights and four cadences studied in the basic step.

Cadence (bpm)	GRF (CW)	
	10 cm	20 cm
136	1,43 ± 0,10	1,68 ± 0,24
140	1,5 ± 0,17	1,73 ± 0,26
144	1,51 ± 0,19	1,74 ± 0,31
152	1,61 ± 0,26	1,8 ± 0,30

CW: corporal weight

The majority of the studies carried out with *Step Training* used slow cadences, inferior to the 136 bpm. Amongst them, Wieczorek, Duarte and Amadio (1997) analyzed the basic step in the speeds of 120 and 132 bpm at the heights of 20 and 30 cm, finding GRF vertical peaks 1,67 ± 0,32 CW. Dyson & Farrington (1995 b) used the height of 20,3 cm with cadence of 120 bpm, getting values of 1,76 ± 0,10 CW. Panda (2001) analyzed some steps of *Step Training* using musical cadence of 126 bpm and height of 15 cm and found vertical peaks of the GRF of 1,61 CW for the basic step.

In our study, the maximum value found for the vertical component of GRF reached 1,80 ± 0,30 CW, on the height of 20 cm and speed of 152 bpm. The relatively raised value compared with literature assumes that the increase of both variables (platform height and movement speed) increases the impact intensity suffered by the locomotor system. However, if we keep the cadence of 152 bpm and reduce the height to 10 cm, this value reduces to 1,61 ± 0,26 CW, and thus, we can guarantee an increase in the intensity of the class.

In Table 2 it is presented results of the influence of movement speed and platform height on the GRF in the simple alternating knee step. Analyzing the vertical lines, we can observe the implications of the musical cadence on GRF. The values found are not statistically significant to $p < 0,05$. As Table 2, values found at the height of 10 cm in the cadences of 136, 140, 144 and 152 bpm were respectively: 1,48, 1,53, 1,52 and 1,64 CW. At the height of 20 cm one met for the same speeds of movement values of: 1,74, 1,75, 1,76 and 1,82 CW. Already when it compares the influence of platform height (horizontal lines), all the cadences presented a significant increase between the heights of 10 and 20 cm: cadence of 136 bpm ($p = 0,0052$), 140 bpm ($p = 0,0118$), 144 bpm ($p = 0,0017$) and 152 bpm ($p = 0.0291$).

Table 2: Average and standard deviation of GRF in the two platform heights and the four cadences studied in the simple alternating knee step.

Cadence (bpm)	GRF (CW)	
	10 cm	20 cm
136	1,48 ± 0,25	1,74 ± 0,30
140	1,53 ± 0,27	1,75 ± 0,25
144	1,52 ± 0,22	1,76 ± 0,27
152	1,64 ± 0,29	1,82 ± 0,30

CW: corporal weight

As in the basic step, the increment height showed to cause greater effect on the increase of the values of GRF in the simple alternating knee step. Panda (2001) also analyzed the rise of knees step on the height of 15 cm and musical cadence of 126 bpm, finding GRF maximum peaks of 1,66 CW. Similar to our study, Mendes (2005) compared movements of knee rising with and without propulsion to a speed of 140 bpm and height of 20 cm. In knees rising without propulsion it was found values of 1,79 CW, similar to 1,75 ± 0,25 on the height of 20 cm and 140 bpm. If we compare the results of GRF vertical component found in this study with the values of the walking and running found in literature, we will be able to observe that the *Step Training* presents values next to walking and inferiors to running. In accordance with Nigg and Herzog (1994), for walking the reported values are from 1,0 to 1,5 CW and for running from 2,0 to 2,5 CW. Using the height of 10 cm platform and slower cadences, the GRF value is next to the standards for walking. Hence in relation to running, according to this study, the *Step Training* presents GRF values inferior to the standards reported by literature.

CONCLUSION

In accordance with the proposed objective, this study concluded, based on the founded results, that the variable platform height implied in the increase of the vertical component of the force of ground reaction in the descending phase of the movement in the two analyzed steps. While the variable execution speed of the movement was not determinative to significantly increase the GRF in the platform heights studied and in both steps. The largest value found was on the height of 20 cm and musical cadence of 152 bpm (1,80 and 1,82 CW) for the basic and simple alternating knee steps respectively, inferior values if compared to the standards of the race that vary between 2,0 and 2,5 CW (Nigg & Herzog, 1994).

As much the platform height as the musical cadence are factors that interfere in the intensity of the class and overload of the locomotor apparatus. Therefore, the teachers of *Step Training* can use of one of the elements (height or speed) to increase the intensity of the class and, at the same time, the possible risks of injuries to the adepts of the modality.

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THE INFLUENCE OF THE STEP HEIGHT AND THE MUSICAL CADENCE ON THE GROUND REACTION FORCE IN TWO MOVEMENTS OF STEP TRAINING

Abstract

INTRODUCTION: The *Step Training* was one of the novelties in the 90s, arising from the adaptation of the Swedish bench by the Professor Gin Miller. The modality consists on going up and down a platform (step), using music to mark the rhythm. OBJECTIVE: Evaluate the implications of different music cadences (136, 140, 144 e 152 bpm) on platform heights of 10 and 20 cm over a vertical component of Ground Reaction Force (GRF) in the basic and simple knee elevation steps in descending movement. METHODOLOGY: It was used two platforms of extensometer forces, one at ground level and another at 10 and 20 cm of the ground and CDs recorded to mark the rhythm. The 5 subjects carried out 12 complete cycles of the two steps in four cadences and two analyzed heights. The data were normalized by the Corporal Weight (CW) of the subjects and the statistics were done with software Statistics version 6.0. The comparison among the values of GRF in the 4 speeds was carried out through the variant analysis test ANOVA One Way. For comparison among platform heights it was used a test "t" of *Student* for independent samples. RESULTS: According to table 1, the values found for GRF in the musical cadence change at the same platform height were not statistically significative to $p < 0,05$ in both steps. Nonetheless, the height elevation caused a significant rising ($p < 0,05$) on the GRF values in all studied speeds except at the height of 10 cm and musical cadence of 152 bpm.

Table 1:

	Basic		Simple knee	
	GRF (CW)		GRF (CW)	
Cadence (bpm)	10 cm	20 cm	10 cm	20 cm
136	1,43 ± 0,10	1,68 ± 0,24	1,48 ± 0,25	1,74 ± 0,30
140	1,5 ± 0,17	1,73 ± 0,26	1,53 ± 0,27	1,75 ± 0,25
144	1,51 ± 0,19	1,74 ± 0,31	1,52 ± 0,22	1,76 ± 0,27
152	1,61 ± 0,26	1,8 ± 0,30	1,64 ± 0,29	1,82 ± 0,30

CW: corporal weight

CONCLUSION: The variable platform height implied on the increasing of GRF in the descending phase of the movement in both analyzed steps. Already, the variable execution speed was not determinant to significantly increase the GRF on platform heights studied in both steps.

Keywords: Step Training, biomechanics, Ground Reaction Force.

L'INFLUENCE DE L'HAUTEUR DU STEP E DE LA CADENCE MUSICAL SUR LA FORCE DE REACTION SUR LE SOL EM DEUX MOUVEMENT DE STEP TRAINING

Resumée

INTRODUCTION: l'exercice de Step Training a été une des plus grandes nouveautés des années 90, originé de l'adaptation du "banc soudeois" par le professeur Gin Miller. Ça consiste des mouvements de monter et descendre d'une plate-forme (step) avec son hauteur possible d'ajuster, en utilisant de la musique pour faire la marcation du rhythme. CIBLE: évaluer les implications de différentes cadences musicaux (136, 140, 144 e 152 bpm) avec des plate-formes mesurant 10 et 20 cm sur le composant vertical de la Force de Reaction du Sol (FRS) dans le pas basique d'élevation de genou simple dans la phase descendente du mouvement. METHODOLOGIE: on a utilisé deux plate-formes de force extensometrique, une posé au niveau du sol et l'autre 10 et 20 cm du sol et des CDs enregistrés pour la marcation du rhytme. Les 5 sujets ont realisé 12 cicles complets du pas basique et celui du genou simple aux quatre cadences analysées et deux hauteurs de plate-forme. Les informations obtenues ont été mises em norme par le Poids Corporal (PC) des sujets et l'estatistique a été faite à travers du Software Statistica version 6.0. La comparaison parmis les valeurs de FRS dans les 4 vitesses a été realisée à partir du Test d'Analyse de Variation ANOVA One Way. Pour les comparaisons parmis les hauteurs de plate-formes a été utilisé le Test "t" de Student pour des amostres dependentes. RESULTATS: Selon la table 1, les valeurs trouvés pour la FRS lors du changemant de la cadence musical sur la même hauteur de la plate-forme n'ont pas été sigificatifs à $p < 0,05$ dans le deux pas. Lorsqu'on a analysé l'influence de l'hauteur de la plate-forme dans une même cadence musicale, l'élevation de l'hauteur a provoqué une augmentation significative ($p>0,05$) dans les valeurs de la FRS dans toutes les vitesses étudiées sauf sur l'hauteur de 10 cm et la cadence musicale de 152 bpm.

Tabele 1:

	Basique		Genou simple	
	FRS (PC)		FRS (PC)	
cadence (bpm)	10 cm	20 cm	10 cm	20 cm
136	1,43 ± 0,10	1,68 ± 0,24	1,48 ± 0,25	1,74 ± 0,30
140	1,5 ± 0,17	1,73 ± 0,26	1,53 ± 0,27	1,75 ± 0,25
144	1,51 ± 0,19	1,74 ± 0,31	1,52 ± 0,22	1,76 ± 0,27
152	1,61 ± 0,26	1,8 ± 0,30	1,64 ± 0,29	1,82 ± 0,30

PC: poids corporal

CONCLUSION: La variation de l'hauteur de la plate-fomre a provoqué l'augmantation de la FRS dans la phase descendente du mouvement dans les deux pas analysés. Mais la variation de la vitesse du mouvement n'a pas été determinante pour augmanter la FRS sur les hauteurs des plate-formes étudiées et dans les deux pas.

Mots-clés: Step Training, Force de reaction du sol et pas.

LA INFLUENCIA DE LA ALTURA DEL STEP Y DE LA CADENCIA MUSICAL SOBRE LA FUERZA DE REACCIÓN DEL SUELO EN DOS MOVIMIENTOS DEL STEP TRAINING.

Resumen

INTRODUCCIÓN: El *Step Training* fue una de las grandes novedades de la década de 90, surgiendo de la adaptación del banco sueco por la Profesora Gin Miller. La modalidad consiste en subir y bajar de una plataforma (step), utilizándose de la música para marcación del ritmo. OBJETIVO: Avaluar las implicaciones de diferentes cadencias musicales (136, 140, 144 e 152 bpm) en las alturas de plataforma de 10 e 20 cm sobre la componente vertical de la Fuerza de Reacción del Suelo (FRS) en el paso básico y elevación de rodillas simples en fase descendente del movimiento. METODOLOGÍA: Fueran utilizadas dos plataformas de fuerza extensométricas, una al nivel del solo y la otra en las alturas de 10 e 20 cm del piso y CD's grabados para marcación del ritmo. Los 5 individuos realizaran 12 ciclos completos de los dos pasos en las cuatro cadencias y dos alturas analizadas. Los dados fueran normalizados pelo Peso Corporal de los individuos y la estadística realizada por el Software Statistica versión 6.0. La comparación entre valores de la FRS en las 4 velocidades fue realizada a través del Teste de análisis de Variancia ANOVA One Way. Para comparaciones entre alturas de la plataforma fue utilizado el Teste "t" de *Student* para muestras dependientes. RESULTADOS: Conforme tabla 1, los valores encontrados para la FRS en mudanza de la cadencia musical en la misma altura de plataforma no fueran estadísticamente significativos a $p < 0,05$ en ambos los pasos. Ya la elevación de la altura causó aumento significativo ($p < 0,05$) en los valores de la FRS en todas las velocidades estudiadas excepto en la altura de 10 cm y cadencia musical de 152 bpm.

Tabla 1:

	Básico		Rodilla simples	
	FRS (PC)		FRS (PC)	
cadencia (bpm)	10 cm	20 cm	10 cm	20 cm
136	1,43 ± 0,10	1,68 ± 0,24	1,48 ± 0,25	1,74 ± 0,30
140	1,5 ± 0,17	1,73 ± 0,26	1,53 ± 0,27	1,75 ± 0,25
144	1,51 ± 0,19	1,74 ± 0,31	1,52 ± 0,22	1,76 ± 0,27
152	1,61 ± 0,26	1,8 ± 0,30	1,64 ± 0,29	1,82 ± 0,30

PC: peso corporal

CONCLUSIÓN: La variable altura de la plataforma implicó en el aumento de la FRS en la fase descendente del movimiento en los dos pasos analizados. Ya la variable velocidad de ejecución no fue determinante para aumentar significativamente la FRS en las alturas de plataforma estudiadas y en ambos os pasos.

Palabras-clave: Step Training, Fuerza de Reacción del Suelo y biomecánica.

INFLUÊNCIA DA ALTURA DO STEP E DA CADÊNCIA MUSICAL SOBRE A FORÇA DE REAÇÃO DO SOLO EM DOIS MOVIMENTOS DO STEP TRAINING.

Resumo

INTRODUÇÃO: O *Step Training* foi uma das grandes novidades da década de 90, surgindo da adaptação do banco sueco pela Professora Gin Miller. A modalidade consiste de movimentos de subida e descida de uma plataforma (step) com altura ajustável, utilizando-se da música para a marcação do ritmo. OBJETIVO: Avaliar as implicações de diferentes cadências musicais (136, 140, 144 e 152 bpm) nas alturas de plataforma de 10 e 20 cm sobre a componente vertical da Força de Reação do Solo (FRS) no passo básico e elevação de joelhos simples na fase descendente do movimento. METODOLOGIA: Foram utilizadas duas plataformas de força extensométricas, uma colocada ao nível do solo e a outra nas alturas de 10 e 20 cm do chão e CD's gravados para marcação do ritmo. Os 5 sujeitos realizaram 12 ciclos completos do passo básico e do passo joelho simples nas quatro cadências analisadas e duas alturas de plataforma. Os dados foram normalizados pelo Peso Corporal (PC) dos sujeitos e a estatística foi feita através do Software Statística versão 6.0. A comparação entre os valores de FRS nas 4 velocidades foi realizada através do Teste de análise de Variância ANOVA One Way. Para as comparações entre as alturas da plataforma foi utilizado o Teste "t" de *Student* para amostras dependentes. RESULTADOS: Conforme tabela 1, os valores encontrados para a FRS na mudança da cadência musical na mesma altura de plataforma não foram estatisticamente significativos a $p < 0,05$ em ambos os passos. Já quando se analisou a influência da altura da plataforma numa mesma cadência musical, a elevação da altura causou aumento significativo ($p > 0,05$) nos valores da FRS em todas as velocidades estudadas exceto na altura de 10 cm e cadência musical de 152 bpm.

Tabela 1:

	Básico		Joelho simples	
	FRS (PC)		FRS (PC)	
cadência (bpm)	10 cm	20 cm	10 cm	20 cm
136	1,43 ± 0,10	1,68 ± 0,24	1,48 ± 0,25	1,74 ± 0,30
140	1,5 ± 0,17	1,73 ± 0,26	1,53 ± 0,27	1,75 ± 0,25
144	1,51 ± 0,19	1,74 ± 0,31	1,52 ± 0,22	1,76 ± 0,27
152	1,61 ± 0,26	1,8 ± 0,30	1,64 ± 0,29	1,82 ± 0,30

PC: peso corporal

CONCLUSÃO: A variável altura da plataforma implicou no aumento da FRS na fase descendente do movimento nos dois passos analisados. Já a variável velocidade de execução do movimento não foi determinante para aumentar significativamente a FRS nas alturas de plataforma estudadas e em ambos os passos.

Palavras-chave: Step Training, Força de reação do solo e passos.