# 166 - THE INFLUENCE OF THE FORCE AND FLEXIBILITY IN THE BEATING OF LEGS AND ITS RELATION WITH THE TOTAL PERFORMANCE OF SWIMMERS OF 100 METERS I SWIM CRAWL

JOVIR LUIS DEMARI ; MARCO AURÉLIO VAZ
FACULDADE DA SERRA GAÚCHA
CAXIAS DO SUL (RS), BRAZIL

## INTRODUCTION

The success of the performance of the swimmer is influenced by his capacity to generate propeller force and to minimize the resistance to the advance in a liquid ambient. This happens with the improvement of the technique, the biomechanics standard and the physical condition of the athlete (Maglischo, 1999). The propulsion in the crawl style depends on the synchronized action of the superior and inferior members. Some studies have examined the magnitude of the contribution of the superior members in the propulsion of it swim crawl (Adrian et al., 1966; Counsilman, 1980a; Toussaint et al., 1992; Maglischo, 1999), and are of consensus, between these researchers, that the action of superior members in the crawl style is highly propulsive and responsible for 70% the 100% of the total propulsion of this style. This has been influencing technician and athlete to dedicate some hours of their daily work, in the water and out of it, to the superior members. The contribution of the action of inferior members (beating of legs) in the propulsion of the crawl style was, for a long time, disrespected or neglected. Counsilman (1980b) told, also, that the beating of legs, in some swimmers, could delay the propulsion reached with the superior members. However, the interest in its contribution for the propulsion and the total performance of the crawl style seems be renewed. (Smith, 1978; Fitzgerald, 1980; Mookerjee et al., 1995; Hull, 1997; Deschodt et al., 1999). The beating of legs has been considered responsible for assisting the alignment of the body and the maintenance of the balance and the horizontal position next to the above-water limit (sustentation of the hip). Counsilman (1980a), when observing swimmers of world-wide level, had already evidenced that seven on eight finalists in the test of 100 meters used, with great intensity, the beating of legs. Although the great amount of oxygen consumed during the action of the inferior members in the crawl style (Adrian et al., 1966; Maglischo, 1999), the beating of legs is very important in the mechanics of the swim styles and the reduction of the force of resistance or drag (Counsilman, 1980a; Maglischo, 1990). The function of the beating of legs in the total performance of the swimmer was investigated by some researchers (Karpovich, 1935; Fitzgerald, 1980; Hollander et al., 1986; Mookerjee et al., 1995; Hull, 1997; Maglischo, 1999). However, the opinions diverge in the accurate magnitude of the contribution of the beating of legs when it is about propulsion. Considering that the beating of legs is integral part of any style of swimming, it is essential a study more specific about subject. Assuming itself that lesser is the time to cover one definitive distance beating legs, greater is the offered propulsion, two factors has been considered as responsible for the difference in the decurrently propulsion of the beating of legs: the flexibility of the joint of the ankle (plantar flexion) (Hull, 1997), and the force of the muscles that act in the beating of legs (Hawley et al., 1992). In this way, the objective of the present study was to investigate the correlation of the force and flexibility in the beating of legs and the influence of the beating of legs in the total performance of swimmers of 100 meters crawl style.

Characterized by a research of the correlation type, therefore it tries to relate the influence of the ankle flexibility (plantar flexion) and of the capacity of force production in the beating of legs, and the relation of it with the total performance of 100 meters crawl style swimmers. The 23 best swimmers had participated of this study, participants of Senior and Junior categories of the 100 meters crawl style competition of the Winter's Júnior and Senior Rio Grande do Sul State's Championship. The ages (average 19 years), their corporal mass (average 78.30 kg), their stature (average 182 cm) and spread (average 194cm) and measures of the proximal thigh perimeters (average 56.60 cm), of the distal thigh (average 53.14 cm), of the leg (average 38.13 cm) and the percentage of fat (average 7.66) had not presented significant difference ($p>0,05$) among the sub-groups of the sample again, demonstrating a homogeneity regarding the anthropometrics measures in the groups.

For the verification of the capacity of production of muscular force of the inferior members, it was used a CYBEX isokinetic dynamometer (Modelo Norm; Lumex, Ronkonkoma, New York). The torque produced by the extensors and flexors knee muscles was used as a force representative of the inferior members. The capacity of force production was evaluated from an isometric and another isokinetic test. The time needed to cover 100 meters using only the beating of legs and the aid of the beating plate (float), was utilized as propulsion representative, and the performance of the swimmer was determined from the time necessary to swim the 100 meters distance swims crawl swim style, where the start point was inside of the swimming pool. Assuming the fact that the individuals that got the execution best times also possess the biggest propulsion. The test was lead in an Olympic 50 meters swimming pool. The test was carried through in pairs, aiming to increase the competitiveness and to stimulate the individuals to get their maximum performance.

## 2. ANALYSIS OF THE RESULTS

The variables used for analysis of the results were: the flexibility of the ankle, the isokinetic torques at 370º/s and isometric torques at 60º, representative of the capacity of force production, the time of beating of legs in 100 meters and the time of the crawl style in 100 meters. Initially, the correlation between the flexibility of the ankle and the time of beating of legs was verified. After that, it was analyzed the existing correlation between the capacity of force production and the time of beating of legs of all the individuals and, finally, it was verified the existing relation between the time of beating of legs and the total performance in 100 meters crawl style. After this proceeding, the sample was divided in three definitive groups determined by the time gotten in the test of beating of legs. The eight best athletes were defined as pertaining to the group one and, the eight following times were defined as group two, and, at last, the seven remaining times were defined as group three. The objective of the division was to verify if the groups were statistically different ($p<0,05$) in relation to their physical characteristics, in the capacity production of force of inferior members, in the plantar flexion, the time of beating of legs and in the total performance concerning the sub-groups. The correlation analysis of the product "Pearson moment" was used to verify the relations among the plantar flexion, capacity of force production and the time of beating of legs and also the existing relations between the time of beating of legs and the total performance of the individual. For the purpose of analyze possible differences in the studied variables among the three groups, stratifications for the time gotten in the test of beating of legs, it was used the Analysis of one Via Variance (ANOVA). In the case of significant differences, it was used a "*Post Hoc*" test using the *Tukey* method. The significance level of $p<0,05$ was adopted for all the cases. For statistics analysis it was used the SPSS.

**3. RESULTS**

**3.1 Right and left plantar flexion**

The evaluations of right and left plantar flexion had not presented significant difference (p<0.05) among the sub-groups of the sample (figure 1). In other words, the flexibility of the ankle plantar flexion was similar for the three groups in both ankles (right and left).

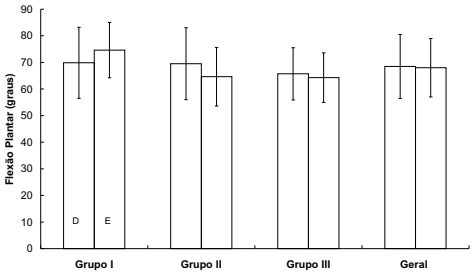



Figure 1 - Measures (average and standard diverge) of the plantar flexion. "D" (right) and "E" (left) of groups I, II, III and Generality (average of all the individuals of the sample).

**3.2 VERIFICATION OF THE CAPACITY OF TORQUE PRODUCTION**

**3.2.1 ISOMETRIC TORQUE**

The values of the maximum isometric force, that is, of the torque resulting from the extension and flexion of the knee in the angle of 60º, had not presented significant difference (p>0.05) among the sub-groups of the sample (figure 2). The capacity of production of force of the extensors and flexors muscles of the joint of the knee was, therefore similar among the three groups.

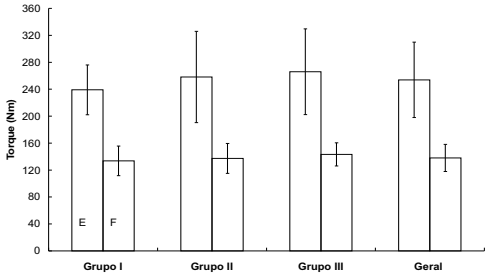



Figure 2 - Values (average and standard diverge) of the resultant torque of the extension (e) and the flexion (f) of the knee in 60°, of groups I, II, III and Generality (of all the individuals of the sample).

**3.2.2 ISOKINETIC TORQUE**

The values gotten from the isokinetic force, that is, from the resultant torque of the extension and flexion of the knee, in the speed of 370°/s, had not presented significant difference (p>0,05) among the sub-groups of the sample (figure 3). The capacity of production of the dynamic force was, therefore, similar among those three groups of the sample, in the two studied muscular groups.

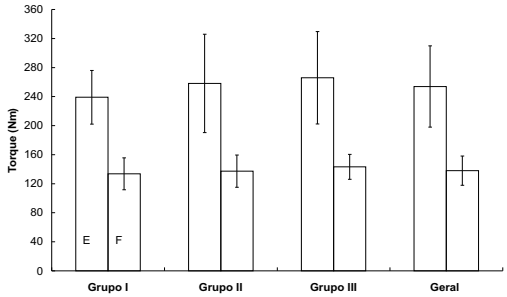



Figure 3 - Values (average and standard diverge) of the resultant torque of the extension (e) and the flexion (f) of the knee in the speed of 370º/s in the three groups of the sample and in all group of athlete (general).

**3.3 TIME OF BEATING OF LEGS**

The values gotten in the test of beating of legs had presented difference (p>0.05) among the sub-groups of the sample (figure 4). Group "I" (best time) was different of group "II" (intermediate time) and of group "III" (worst time); and group "II" was also different of group "III". The time of beating of legs was different, wherefore, among the three groups.

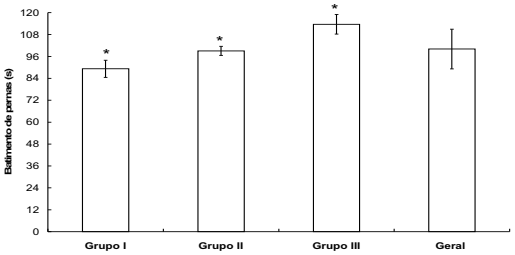



Figure 4 - Values gotten in the test of beating of legs, in the sample and the sub-groups (*= p<0,05).

**3.4 TOTAL PERFORMANCE**

The statistic analysis disclosed that the values of group "I" performances are not different of group "II" (p>0.05), but

they both differ from group "III" (p<0.05). Moreover, the values of group "II" are not different from group "III" (figure 5). Therefore, there is a difference in the performances only in the performance values concerning groups "I" and "III".

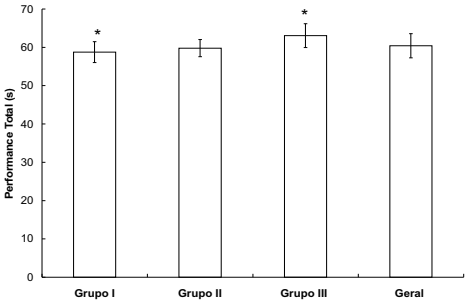



Figure 5 - Gotten values of the performance in 100 meters, I swim crawl, in the sample and sub-groups (* = p< 0,05).

**3.5 PLANTAR FLEXION AND BEATING OF LEGS**

As it did not exist any difference in the flexibility of the ankle between the right and left sides, for the correlation between plantar flexion and beating of legs, it was used only the values of plantar flexion of the right ankle. The values gotten for the correlation in the group of the sample (r=-0.38) had all not been statistically significant (p>0.05) (figure 6).

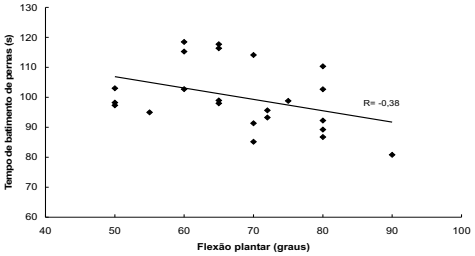



Figure 6 - Correlation between plantar flexion and beating of legs for all the sample.

However, the correlation between flexion plantar and the time of beating of legs in the groups stratified by the result of the test of beating of legs had got significant correlation for group "I" (r=-0.70). Between groups "II" (r=0.24) and "III" (r=0.26) it had not been noticed results statistically significant (p> 0.05) (figure 7).

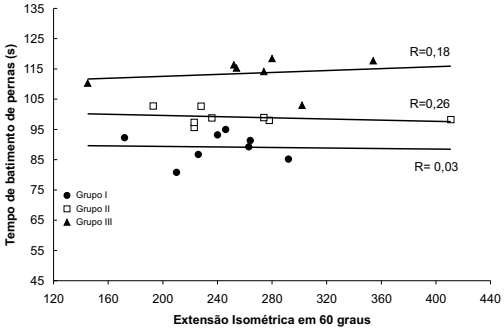



Figure 7 - Correlation between plantar flexion and beating of legs, in the sub-groups of the sample (* = p<0.05).

**3.6 CAPACITY OF FORCE PRODUCTION AND BEATING OF LEGS**

The values of the torque resultant from the flexion and extension of the knee in 60º (isometric torque) and the speed of 370º/s (isokinetic torque), representatives of the capacity of force production, had not been correlated with the times gotten in the test of beating of legs, as in the whole group (attached 8), as in the stratified groups (figures 8, 9, 10 and 11).

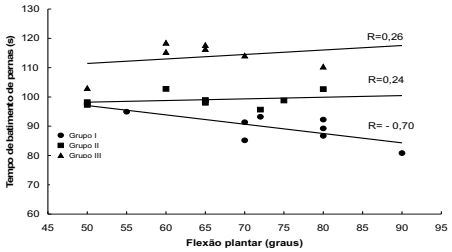



Figure 8 - Correlation of the torque resultant from the knee extension in 60º and the time of beating of legs in the sub-groups.

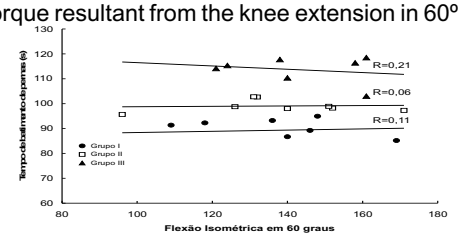
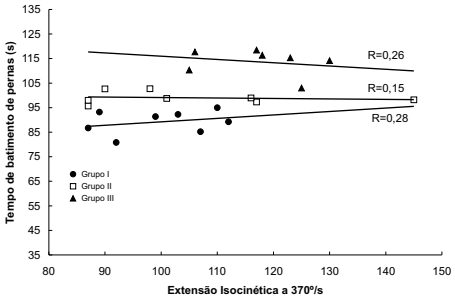



Figure 9 - Correlation of the torque resultant from the knee flexion in 60º and the time of beating of legs in the sub-

groups.




9 - Correlation of the torque resultant from the knee flexion in 60º and the teams of beating of legs in the sub-groups.

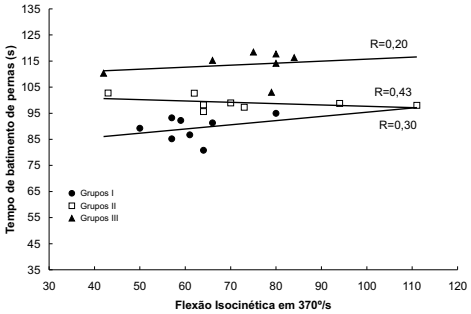



Figure 11 - Correlation of the torque resultant from the knee flexion in 370º/s and the time of beating of legs in the sub-groups.

**3.7 BEATING OF LEGS AND TOTAL PERFORMANCE**

The values of time of beating of legs had shown correlation statistically significant (r=0.70) with total performance for the sample (figure 12).

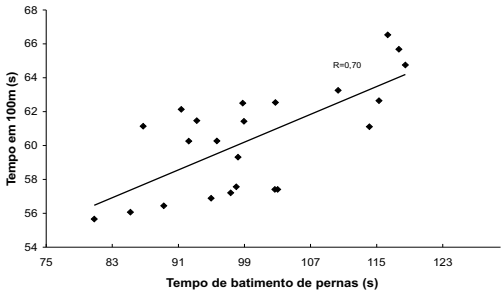



Figure 12 - Correlation between time of beating of legs and total performance measured through the time of 100 meters crawl style.

The correlation between beating of legs and total performance in the sub-groups statistically showed significant values for group "III" (p>0.05), but did not show significant values for this correlation in groups "I" and "II" (figure 13).

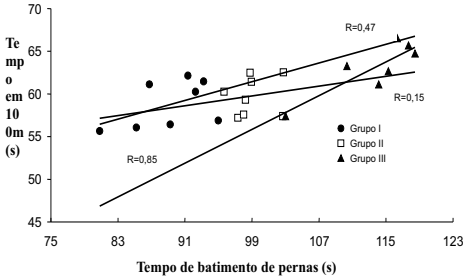



Figure 13 - Correlation between beating of legs and total performance in 100 meters crawl style in the sub-groups (*p>0.05).

**4. CONTROVERSY**

Accordingly to the first hypothesis of the present study, it was expected to find correlation between the ankle flexibility and the beating of legs, bearing in mind that it has been suggested in the literature that a bigger flexibility would result a lesser time of beating of legs (Fitzgerald, 1980; Hull, 1997; Maglischo, 1999). The values found for the plantar flexion (figure 1) had not been different among the sub-groups of the sample, demonstrating a level of ankle flexibility very similar among the three groups of athletes. It had not been found any correlation between general flexibility and the values gotten in the test of beating of legs (figure 6), what apparently could be interpreted as a total inexistence of relation between flexibility and beating of legs, not confirming, therefore, the hypothesis number 1. However, after the stratification of the groups, it was observed correlation between flexibility and beating of legs (r=0.70; p<0,05; figure 7). Yet in groups "II" and "III", the correlations had not been statically significant (p>0.05). These results only had confirmed the hypothesis only group "I", and not for groups "II" and "III". Some authors (Fitzgerald, 1980; Hull, 1997; Maglischo, 1999) had described that the plantar flexion is important for good propulsion deriving from the beating of legs. Maglischo (1999) had also suggested that a good plantar flexion is at least that one of 70 degrees. Hull (1997) had divided the beating of legs in "bad", "moderate" and "excellent" that ones, respectively, inferior than 90 degrees, 90 degrees and greater that 90 degrees of plantar flexion. The studied sample had presented an average of 69º of ankle plantar flexion, what is near to the values suggested by Maglischo (1999), but is distant from the values suggested by Hull (1997). This

proposes that, according to Hull (1997), the sample must advance in this aspect, but in agreement with Maglischo (1999), the results are connected with good flexibility. The comparison between these reports, however, must be carried through with caution; therefore the mentioned authors had not demonstrated studies about this subject. The second hypothesis of the study had considered that individuals with bigger capacity of force production would present greater propulsion deriving from the beating of legs. Concerning the capacity of isometric and isokinetic force (torque) production, it had not been observed significant differences ($p>0.05$) for isometric and isokinetic torques resulting from the knee flexion and extension among the sub-groups (figures 2 and 3). Moreover, it had not been found any significant correlation ($p>0.05$) between the torque and the beating of legs (figures 8 the 11). These results suggest that it does not exist any relation between capacity of production of force (in the conditions studied here) and the beating of legs, not confirming, therefore, the second hypothesis. The fact of exists significant differences ($p>0.05$) among the sub-groups for the variable "beating of legs" (figure 4), but does not exist difference for the flexibility and capacity 2of force production, further the fact of does not exist correlation between these two variables and the beating of legs, suggests that other variables are, perhaps, more important concerning the determination of the recurrent propulsion of the beating of legs. Our results, therefore, do not confirm the affirmations of Hawley (1992) and of Mookerjee (1995), when they say that the force is the determinative factor for a better time of beating of legs, but partially confirms the affirmations of Hull (1997) and Maglischo (1999) when they sat that the plantar flexion is a determinative factor for improvement of the time of beating of legs. However, Mookerjee (1995), had observed significant correlations (in his study with swimmers) in the torques generated at 6.28 rad./s (360º/s) and beating of legs in the distances of 25 and 50 yards. Perhaps the expected correlation existed only for lesser distances, where the muscular fatigue could not intervene with the force results. Accordingly to the third hypothesis of this study, swimmers with better times of beating of legs would present better performances in a passage of 100 meters crawl style. The suppositional existence of correlation between beating of legs and the performance of the individuals (figure 12) apparently demonstrate the importance of the beating of legs for the total performance, confirming the hypothesis above. However, the correlation between beating of legs and total performance in the sub-groups statistically showed significant values only for group "III", and it did not show significant values for this correlation in groups "I" and "II". These results only confirm the third hypothesis for group "III" and it does not confirm it for groups "I" and "II", not giving solidity to the correlation presented for the sample, for the fact of groups "I" and "II" are the groups with lesser time of beating of legs and does not exist correlation in it. If we observe the performance values, we can easily verify that there are significant differences between groups "I" and "III", but it could not be found differences between groups "I" and "II" and between groups "II" and "III" (figure 5). These data suggest that the performance results gotten by groups "I" and "II" could have been influenced for another variable but beatings of legs, while in group "III" the beating of legs is influencing directly the reached performance. The propulsion of superior members seems to be a strong candidate to explain the results of groups "I" and "II", knowing that they have better times of beating of legs than group "III", but the total performance are similar in groups "I" and "II". However, as the superior members propulsion was not studied separately, was not possible to estimate this possibility. The difference existing between groups "I" and "III" also can be observed relating to time of the beating of legs, demonstrating, in such a way, other factors, as the movement technique, for example, can be influencing the results obtained by the groups.

## 5. CONCLUSION

The results of this study had shown that the flexibility represented by the plantar flexion of ankle did not influence the beating of legs of the sample. When stratified in groups, it was only observed correlation for group "I". The capacity of force production, represented by the isometric and isokinetic torque, resultant of the knee flexion and extension, did not influence the beating of legs in the two situations, as for the whole group, as for the sub-groups. The beating of legs influenced the total performance of swimmers of 100 meters crawl style, indicating that swimmers who present the best beating of legs, also present the best total performance. In the sub-groups, the beating of legs only influenced the performance of group "III".

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JOVIR LUIS DEMARI
RUA AMBRÓSIO LEONARDELLI, 470
CEP 95012060 - CAXIAS DO SUL/RS
BRASIL
EMAIL - JOVIR.DEMARI@FSG.BR

**THE INFLUENCE OF THE FORCE AND FLEXIBILITY IN THE BEATING OF LEGS AND ITS RELATION WITH THE TOTAL PERFORMANCE OF SWIMMERS OF 100 METERS I SWIM CRAWL**

SUMMARY

The objective of this study was to verify the influence of the force and flexibility in the beating of legs and its relation with the performance of 100m crawl style swimmers. The 23 best swimmers in the test of 100 meters crawl style (also known as freestyle) of the State of Rio Grande do Sul (Brazil) had been selected for this study and submitted to the evaluation of flexibility, capacity of force production, beating of legs and performance of crawl style in the distance of 100m. It had been analyzed the influence of the force and flexibility in the beating of legs, and the influence of the beating of legs in the swimmers total performance. After it, the sample was divided in three groups, as the time gotten in the test of beating of legs (group I: of 1º to 8º time; group II: of 9º to 16º time; e group III: of 17º to 23º time), with the objective to verify differences among the groups in the tested variables. The values gotten (n=23) from the correlation between plantar flexion and beating of legs had not been significant. In the sub-groups, only group "I" got significant correlation (r=0,70 - p<0,05) between plantar flexion and beating of legs. The values gotten from the force had not been correlated with the results gotten from the test of beating of legs, as much in the analysis of the whole group, as in the extracted groups. The times of beating of legs (n=23) had shown significant correlation (r=0,70 - p<0,05) with the total performance. The analysis made in the sub-groups only showed significant values for group "III" (r=0,85 - p<0,05), but did not show significant values for groups "I" and "II". The results suggested that the force does not have influence in the beating of legs, while flexibility influenced the beating of legs only in group "I", and that the total performance of swimmers of 100m crawl the beating of legs had indeed a significant importance in this study.

Key Words: swimming, flexibility, force.

**L' INFLUENCE DE LA FORCE ET DE LA FLEXIBILITÉ AU BATTEMENT DE JAMBES ET LEUR RELATION AVEC LA PERFORMANCE TOTALE DES NAGEURS DE 100 MÈTRES NAGE CRAWL**

RESUMÉ

L" obejectif de cette étude a été de verifier l' influence de la force et de la flexibilité au battement de jambes et leur relation avec la performance des nageurs de 100m crawl. Les 23 meilleurs nageurs, dans l'épreuve de 100m crawl du Rio Grande do Sul, ont été sélectionnés pour cette étude et soumis à l'évaluation de la flexibilité, de la capacité de production de force, du battement de jambes et de la performance du nage crawl dans une distance de 100m. L' influence de la force et de la flexibilité au battement de jambes, et l' influence au battement de jambes dans la performance totale des nageurs ont été analysées.

Après l' échantillon a été divisé en trois groupes, selon le temps obtenu dans le test du battement de jambes ( groupe I: du I er au 8ème temps ; groupe II: du 9 ème au 16ème; et groupe III: du 17ème au 23ème temps), avec l' objectif de vérifier les différences entre les groupes aux variables testées. Les valeurs obtenues (n= 23) pour la corrélation entre flexion plantaire et le battement de jambes n' ont ps été significatives. Dans les sous-groupes seulement le groupe I a obtenu une corrélation significative ( r = 0,70 - p <0,05 )

entre flexion plantaire et battement de jambes. Les valeurs obtenues de la force ne se sont pas corrélationnées avec les résultats obtenus dans le test du battement de jambes aussi bien dans l' analyse de tout le groupe, que dans les groupes stratifiés. Les temps du battement de jambes (n=23) ont montré corrélation significative (r = 0,70 - p, 0,05) avec la performance totale. L' analyse de sous-groupes a montré des valeurs significatives seulement pour le groupe III (r = 0,85 - p < 0,05), mais cette analyse n' a pas montré des valeurs significatives pour les groupes I et II. Les résultats suggèrent que la force n' a d' influence qu' au battement de jambes pendant que la flexibilité exerce de l' influence au battement de jambes seulement dans le groupe I et à la performance totale de nageurs de 100m crawl, le battement de jambes a eu une importance significative dans les résultats.

Mots clés: natation, flexibilité , force.

**LA INFLUENCIA DE LA FUERZA Y DE LA FLEXIBILIDAD EN EL GOLPE DE LAS PIERNAS Y SU RELACIÓN CON EL DESEMPEÑO TOTAL DE LOS NADADORES DE 100 METROS CRAWL.**

RESUMEN

El objetivo del estudio fue verificar la influencia de la fuerza y de la flexibilidad en el golpe de las piernas y su relación con el desempeño de los nadadores de 100 mts crawl.Los 23 mejores nadadores en la prueba de 100 mts de "Rio Grande do Sul", fueran seleccionados para este estudio y submetidos a una prueba de flexibilidad , de capacidad de producción de fuerza , de golpe de piernas y el desempeño del nado en la distancia de 100 mts.. La influencia de la fuerza y el desempeño en el golpe de piernas y la influencia en el golpe de piernas y el desempeño total de los nadadores fueron analizados. Después la muestra fue dividida en tres grupos ; conforme el tiempo obtenido en el tes de golpe de piernas el ( Grupo I : 1º a 8º tiempos ; Grupo II : 9º a 16º tiempos y Grupo III : 17º a 23º tiempos) con el objetivo de ver diferencias entre los grupos en las variables testadas . Los valores obtenidos (n = 23 ) para correlación entre flección plantar y golpe de piernas no fueron muy significativos. En los subgrupos solamente el grupo I obtuvo correlación significativa (R=0,70 - p < 0,05) entre flección plantar y el golpe de piernas. Los valores obtenidos en la fuerza no se relacionan con los resultados obtenidos en el tes de golpe de piernas, tanto en el análisis del grupo , como en los grupos estratificados. Los tiempos de golpe de piernas (n=23) mostraron relación significativa (R = 0,70 - p < 0,05) con el desempeño total. El análisis en los subgrupos mostró valores significativos para los grupos I y II . Los resultados sugieren que la fuerza no tiene influencia en el golpe de piernas pero si el desempeño está influenciando solamente en el grupo I , y en el desempeño total de los nadadores de 100 mts. Crawl , el golpe de piernas tuvo una importancia fundamental en los resultados.

Palavras claves: natación , flexibilidad , fuerza.

**A INFLUÊNCIA DA FORÇA E DA FLEXIBILIDADE NO BATIMENTO DE PERNAS E SUA RELAÇÃO COM A PERFORMANCE TOTAL DE NADADORES DE 100 METROS NADO CRAWL**

R E S U M O

O objetivo do estudo foi verificar a influência da força e da flexibilidade no batimento de pernas e sua relação com a performance de nadadores de 100m crawl. Os 23 melhores nadadores, na prova de 100 metros crawl do Rio Grande do Sul, foram selecionados para este estudo e submetidos a avaliação da flexibilidade, da capacidade de produção de força, do batimento de pernas e da performance do nado crawl na distância de 100m. A influência da força e da flexibilidade no batimento de pernas, e a influência do batimento de pernas na performance total dos nadadores foram analisadas. Após a amostra foi dividida em três grupos, conforme tempo obtido no teste de batimento de pernas (grupo I: do 1º ao 8º tempo; grupo II: do 9º ao 16º tempo; e grupo III: do 17º ao 23º tempo), com o objetivo de verificar diferenças entre os grupos nas variáveis testadas. Os valores obtidos (n=23) para correlação entre flexão plantar e batimento de pernas não foram significativos. Nos subgrupos somente o grupo I obteve correlação significativa (r=0,70 - p<0,05) entre flexão plantar e batimento de pernas. Os valores obtidos da força não se correlacionaram com os resultados obtidos no teste de batimento de pernas, tanto na análise do grupo todo, quanto nos grupos estratificados. Os tempos de batimento de pernas (n=23) mostraram correlação significativa (r=0,70 - p<0,05) com a performance total. A análise nos subgrupos mostrou valores significativos somente para o grupo III (r=0,85 - p<0,05), mas não mostrou valores significativos para os grupos I e II. Os resultados sugerem que a força não tem influência no batimento de pernas, enquanto a flexibilidade esta influenciando no batimento de pernas somente no grupo I, e na performance total de nadadores de 100m crawl, o batimento de pernas teve importância significativa nos resultados.

Palavras Chaves: natação, flexibilidade, força.