EFFECTS OF EXTERNAL LOADING ON POWER OUTPUT DURING VERTICAL JUMP: A PILOT STUDY WITH WATER POLO GOAL KEEPERS.

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The purpose of this study was to describe preliminary results of the effects of external loading on power output during vertical jumps performed on a force platform by three elite water polo goal keepers (1 female and 2 male). Peak power output was calculated from time-force curves during vertical jumps with and without external additional loads corresponding to 0%, 5%, 10% and 15 % of their body weight. The jumps were performed from a squat position, without lower limb counter-movement or arm swings. The peak instantaneous power was reached at 0% additional load (body weight) by two of the athletes, and for the third, the peak instantaneous power was reached at 5% additional load. This study suggests that for water polo goal keepers, the load that generates maximum power output in dry land exercises is body weight, without any additional load.

KEY WORDS: water polo, vertical jump, power output.

INTRODUCTION:

Platanou (2005) described that the performance of the water polo athletes in the water vertical jump correlates poorly with the height assessed in the dry-land vertical jump. However, for goal keepers this can be an important variable because these athletes need to jump great heights and train with heavier loads than the others players. Thus, many coaches have applied external loading during physical training. But, assuming that power is the product of force and velocity, some studies have shown that to increase power output athletes should train with velocity and resistance that maximizes mechanical power output (Kawamori and Haff, 2004; Cormie et al. , 2006). Thus, based on power output during vertical jumps performed on a force platform, this paper described preliminary results of the effects of external loading through a cross-sectional pilot study. The variables peak power output, peak velocity, peak force and jump height were assessed among three elite water polo goal keepers.

MATERIALS AND METHODS

Three goal keepers (1 female and 2 male) from the national team volunteered to take part in this study. Their age, sex, and physical characteristics are shown in table 1.

Table 1 - Physical characteristics of the goal keepers (1 female and 2 male)

ATHLETE (sex)	AGE (years)	BODY MASS (Kg)	HEIGHT (cm)	% BODY FAT
1-Woman	19	60	165	17,71
2-Man	14	64	179	13,28
3-Man	26	89	190	18,48

Peak instantaneous output power, peak instantaneous velocity and peak instantaneous force were determined during standardized vertical jumps with both legs, performed on an AMTI force platform. Power calculation used the measurement of the vertical force in addition to the subjects weight (including any objects they were holding) to determine the net force acting on the body. By applying Newton's second law (F=M.A) the acceleration of the body was calculated using vertical force and body mass. Vertical velocity was subsequently determined by integrating the acceleration. The output power was calculated by using the vertical velocity and the vertical force. Peak instantaneous power output corresponded to the highest instantaneous power output before take-off at each load during three jumps. Peak instantaneous velocity and peak instantaneous force did not correspond with the values used to calculate peak instantaneous output power, but, as stated by Driss et al. (2001) these values presented a very similar pattern. The maximal height was assessed by the use of a jump test platform that automatically calculated this variable from the time spent in the air and was placed over the force platform. Force data was sampled at 500 Hz for a total of 3s. The jumps were performed from a squat position with the heels on the platform and the thighs in a horizontal position. Lower limb counter-movement and swinging of the arms were not allowed; the participants grasped the collar of their shirts with their hands. The external loads were put on a special belt and the participants jumped with no load (0%), or an external load corresponding to 5%, 10% or 15% of their relevant body weight. The loads were distributed on the trunk in accordance with previous standardization (Driss et al., 2001). After a warm-up they performed three vertical jumps at each load with at least 90 s between jumps in random order. Participants were encouraged to reach a maximum height with every trial in an attempt to maximize power output. For each load the best trial was that corresponding to the highest peak instantaneous power.

RESULTS

Values of peak instantaneous power in the different loading conditions are reported in table 2.

Table 2 – Power output in the different loading conditions

Athletes	Load (% BW)*	Peak Power ($W \cdot kg^{-1}$)
1	**0**	44,48
	5	39,71
	10	39,56
	15	37,82
2	**0**	51,00
	5	54,58
	10	46,73
	15	44,48
3	**0**	52,02
	5	50,29
	10	50,05
	15	45,15

* Load (kg) = Body weight + additional load

For Athletes 1 and 3 peak instantaneous power at 0% was visually higher than at 5%, 10% and 15%. Athlete 1 (female) showed a greater relative decrease in peak instantaneous power for the first load (11%) than Athlete 3 (male)(4%); both presented no relative differences between the values for 5% and 10%, and the same relative decrease for the last load. Athlete 2 showed an increase in peak instantaneous power for the first load (7%) followed by a decrease of 8%, and then for the last load presented a relative value very similar to the other two athletes.
Values of peak force, peak velocity and height assessed in the vertical jump for the different loading conditions are shown in Figures 1, 2 and 3. Maximum force was obtained during the heaviest loading condition for the male athletes. The female athlete showed maximum force during the load corresponding to an additional 5% of her body weight. Peak velocity showed different patterns for the three athletes, but at 10% and 15% additional load peak velocities

were visually lower than at 0% load for all the athletes. Height was maximized during the body weight condition (0%) for all the athletes.

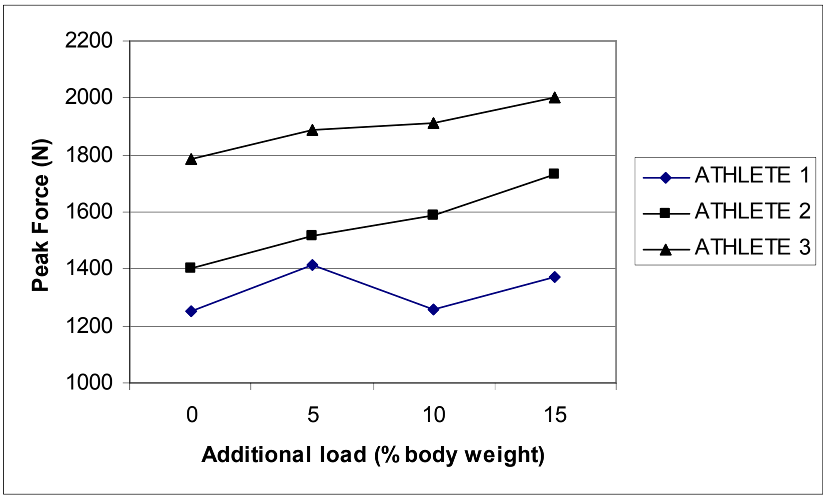

Figure 1 - Relationship between peak Force (absolute) and load expressed as a percentage of each of the three athletes' body weight.

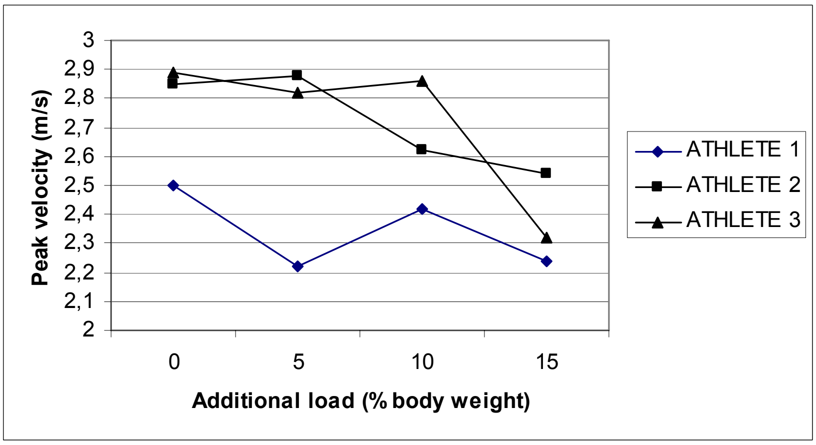

Figure 2 - Relationship between peak velocity and load expressed as a percentage of each of the three athletes' body weight.

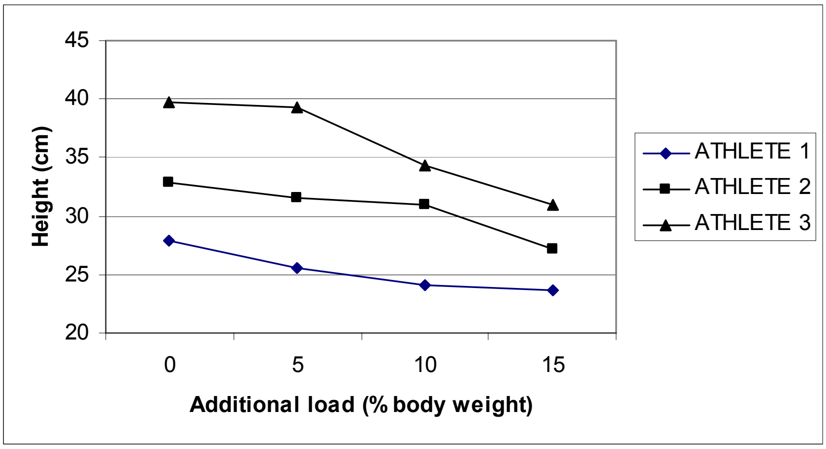

Figure 3 - Relationship between height attained in the vertical jump and load expressed as a percentage of each of the three athletes' body weight.

DISCUSSION:

Although many investigators support the idea of using the optimal load to develop maximum mechanical power output, there is inconsistency in what the optimal load to generate the highest power production is (Kawamori and Haff, 2004). The results of the current investigation identified the optimal load as 0% of the body weight with the exception of Athlete 2 who showed this value for 5%. The values of peak power were a little lower than for volleyball players and weight lifters, but higher than the described for sedentary males and females (Driss et al., 2001). Driss et. al. (2001) described that for sedentary males and females' peak instantaneous power in a squat jump at 0 kg external load was significantly higher than at 5 and 10 kg, but the differences at 0, 5, and 10 kg were not significant within strength and power athletes. Cormie et al (2007) identified the optimal load in the jump squat for athletes as 0% of 1 RM. In contrast Stone et al. (2003) reported the optimal load for the jump squat as being 10% of 1RM. So, body weight alone could possibly correspond to a resistance high enough for the production of maximal mechanical power output. Driss et al. (2001) described that the increases in peak force were almost equal to the external loading for the athletes, which was not the case in our study. Forces presented by the athletes were much greater than the additional load. Peak velocities were supposed to decrease significantly with increasing loading (Driss et al, 2001; Cormie et al., 2007) which did not happen, at least visually speaking, especially for the female athlete. For all the athletes the values are very close, and without a greater sample we can not ensure if they really are different. The height of the jump was lower than the average described by Platanou (2005), but the comparison between the two studies is difficult because the subjects from our research performed the vertical jump without lower limb counter-movement or swinging of the arms.

CONCLUSION

Due to the small sample size, the results may not be considered as strong evidence that, for water polo goal keepers, the load that generates maximum power output in dry land exercises is body weight without any additional load. We also know that the numerical differences found between conditions for all the subjects, especially for Athlete 3, may be within the variability of the measurement. However, we emphasize that the load that generates maximum power output should be taken into account when designing a program to improve maximal muscular power, because training at this load is most effective in improving maximal power output. This study suggests that this program should be the same proposed for sprinters and jumpers, who, as the goal keepers, are required to move light loads at high velocities. For future studies we intend to enlarge the sample as well as investigate other athletes who often use the vertical jump in their training programs.

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