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Performance Changes of Elite Paralympic Judo Athletes During a Paralympic Games Cycle: A Case Study with the Brazilian National Team

by
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The aim of this study was to describe the variations in power performance of elite Paralympic judo athletes across three consecutive training cycles of preparation for the ParaPan American Games, the World Championship and the Paralympic Games. Eleven Paralympic judokas from the Brazilian National team participated in this study. They were repeatedly assessed using squat and countermovement jumps, mean propulsive power (MPP) in the jump-squat (JS), the bench press and prone bench pull at several moments of the preparation. Training supervision based on the optimum power zone (range of loads where power production is maximized) was provided in the final cycle, prior to the Paralympic Games. Magnitude-based inference was used to compare the repeated measurements of power performance. Lower and upper limb muscle power gradually increased throughout the cycles; however, the best results in all exercises were observed prior to the Paralympic Games, during which the team won four silver medals. As an illustration, prior to participation in the Paralympic Games the MPP in the JS was likely to very likely higher than prior to the World Championship (effect size [ES] = 0.77) and ParaPan American Games (ES = 0.53), and in January and March 2016 (ES = 0.98 and 0.92, respectively; months preceding the Paralympic Games). Power performance assessments can provide information about the evolution of Paralympic judokas, and training at the optimum power zone seems to constitute an effective method to improve lower and upper limb power in these athletes.

Key words: *martial arts, blind athletes, Olympic sports, strength-power training, long-term training.*

Introduction

Judo is a grappling combat sport characterized by throwing and groundwork techniques and high physiological demands. Especially during the stand combat phase, judokas need to produce high levels of power to be successful in their throwing actions and score (Franchini et al., 2013). In the Paralympic Games, judo is exclusively practiced by visually impaired athletes, and the main rule change compared to Olympic judo is that athletes start the matches with both hands gripping the opponent's uniform (judogi). Furthermore, when there is total grip disruption, the combat is interrupted by the official judge (Gutierrez-Santiago et al., 2011). Thus, compared to Olympic judo (Miarka et al., 2012), the Paralympic matches present longer isometric actions (Loturco et al., 2017a) and pauses (Gutierrez-Santiago et al., 2011), and may rely more on neuromuscular abilities than on anaerobic capacity. In a recent study comparing

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Olympic and Paralympic judokas, it was reported that these groups did not differ in relation to their maximal isometric strength (Loturco et al., 2017a), but the Paralympic athletes presented lower levels of relative power.

Considering the time-motion characteristics of Paralympic judo (Gutierrez-Santiago et al., 2011), well-developed isometric strength in Paralympics (Loturco et al., 2017a), probable less anaerobic endurance solicitation during the matches (Franchini et al., 2013; Gutierrez-Santiago et al., 2011) and the need to produce higher power outputs to score in judo (Zaggelidis and Lazaridis, 2012), the main training focus of Paralympic judokas (concerning neuromechanical abilities) seems to be power development, which has also been reported as a discriminant factor in Olympic judo (Franchini et al., 2011; Zaggelidis and Lazaridis, 2012). Nevertheless, no study was found analyzing the development of muscle power across a competitive season in Paralympic judokas. Thus, the main objective of this study was to describe the variations in power performance of elite Paralympic judokas throughout a competitive training season including such important events as the ParaPan American Games, the World Championship and the Paralympic Games.

Methods

Participants

Eleven Paralympic judo athletes from the Brazilian National Team participated in this study. The functional classes and characteristics of the subjects are presented in Table 1. The athlete or a legal representative signed the consent form. The study was approved by the Local Ethics Committee.

Study design

This was a longitudinal study where the judo athletes were assessed during a three-year cycle in different moments of the season. Prior to participation in the Paralympic Games, the athletes were involved in two other important competitions: World Championship (August, 2014) and ParaPan American Games (July, 2015). Athletes arrived at the laboratory in the morning (9 a.m.) in a fasting state (2 h). After a standardized warm-up, the athletes performed the tests in the following order: squat and countermovement jumps (SJ and CMJ), jump squat (JS), bench press (BP) and prone bench pull (PBP) exercises (with assessment of mean propulsive power [MPP]).

Vertical jumps

Vertical jumping height was determined using the SJ and CMJ. In the SJ, athletes were required to remain in a static position with a 90° knee flexion angle for ~2 s before jumping, without any preparatory movement. In the CMJ, the participants were instructed to execute a downward movement followed by a complete extension of the legs and were free to determine the countermovement amplitude to avoid changes in jumping coordination. The SJ and CMJ were executed with the hands on the hips. All jumps were performed on a contact platform (Smart Jump; Fusion Sport, Coopers Plains, Australia). A total of five attempts were allowed for each jump, interspersed by 15 s intervals. The best attempts of the SJ and CMJ were used for further analysis.

Bar mean propulsive power

Bar mean propulsive power (MPP) was assessed in the jump squat (JS), bench press (BP) and prone bench pull (PBP) exercises, all being performed on a Smith machine (Hammer Strength Equipment, Rosemont, IL, USA). Participants were instructed to execute 3 repetitions at maximal velocity for each load, starting at 40% of their BM in the JS and PBP and at 30% of their BM in the BP. In the JS, participants executed a knee flexion until the thigh was parallel to the ground and, after the command to start, jumped as fast as possible without their shoulder losing contact with the bar. During the BP, athletes were instructed to lower the bar in a controlled manner until the bar lightly touched the chest and, after the command to start, move the bar as fast as possible. In the PBP, athletes were required to assume a standing position, maintain the trunk parallel to the ground and the knees slightly flexed while pulling the bar against the chest after holding the bar with the arms extended (i.e., initial position). A load of 10% of BM for the JS and PBP and 5% of BM for the BP was progressively added in each set until a decrease in MPP was observed (demanding, on average, from 2 to 5 attempts for all exercises). A 5 min interval was provided between sets. To determine MPP, a linear transducer (T-Force, Dynamic Measurement System; Ergotech Consulting S.L., Murcia, Spain) was attached to the Smith machine bar. Equipment details are described elsewhere (Loturco et al., 2016b, 2017b). We considered the maximum MPP value obtained in each exercise for further data analysis. To consider the differences in body mass between the athletes and avoid misinterpretation of the power outputs, these values were normalized by dividing the absolute power value by body mass (i.e., relative power = W·kg^{-1}) (MPP_{REL}).

Statistical analyses

Data are presented as mean ± standard deviation (SD). To analyze the differences in the test performances across the different periods of assessments, inference based on magnitude was calculated (Batterham and Hopkins, 2006). This magnitude-based inference was chosen since it allows the emphasis of effect magnitude and estimate precision, focusing on non-effect interpretation rather than on absolute effect. In addition, the magnitude-based method defines the practical effect, allowing the researcher to qualify and/or quantify the probability of a worthwhile effect with inferential descriptors to aid interpretation. This analysis recognizes sample variability and provides scientists and professional coaches with an indication of the practical meaningfulness of the outcomes with a reduced risk of bias when assessing small sample sizes (Hopkins and Batterham, 2016). The quantitative chances of finding differences in the variables tested were assessed qualitatively as follows: <1%, almost certainly not; 1 to 5%, very unlikely; 5 to 25%, unlikely; 25 to 75%, possible; 75 to 95%, likely; 95 to 99%, very likely; >99%, almost certain. If the chances of having better and poorer results were both >5%, the true difference was assessed as unclear. A likely difference (>75%) was considered as the minimum threshold to detect meaningful differences. The standardized differences based on Cohen's *d* effect sizes (ES) (Cohen, 1988) were calculated to analyze the magnitude of the differences across the different periods of assessments. The ES values were qualitatively interpreted using the following thresholds: <0.2, trivial; 0.2 – 0.6, small; 0.6 – 1.2, moderate; 1.2 – 2.0, large; 2.0 – 4.0, very large and; >4.0, nearly perfect (Hopkins et al., 2009). Further details of both analyses had been extensively reported elsewhere (Loturco et al., 2016b, 2017a; Pereira et al., 2016).

Results

Figure 1 depicts the jump performances. The SJ performance was very likely lower before the ParaPan American Games than prior to the World Championship (ES = 0.42). Prior to the Paralympic Games the SJ performance was likely to very likely higher than before the World Championship (ES = 0.34) and ParaPan American Games (ES = 0.71), and throughout the months leading up to the Paralympic Games in 2016 (ES varying from 0.27 to 0.82). The CMJ was likely higher before the World Championship than in June 2013 (ES = 0.47). In the assessment performed prior to the Paralympic Games the CMJ performance was likely to very likely higher than prior to participation in the World Championship (ES = 0.32) and ParaPan American Games (ES = 0.45), and throughout the year 2016 (ES varying from 0.36 to 0.70).

Table 1

Characteristics of the subjects and the number of athletes in each functional class of elite Paralympic judo athletes.

Age (years)	Body height (cm)	Body mass (kg)	Class		
			B1 (n)	B2 (n)	B3 (n)
30.5 ± 8.0	172.5 ± 10.0	79.3 ± 26.4	6	2	3

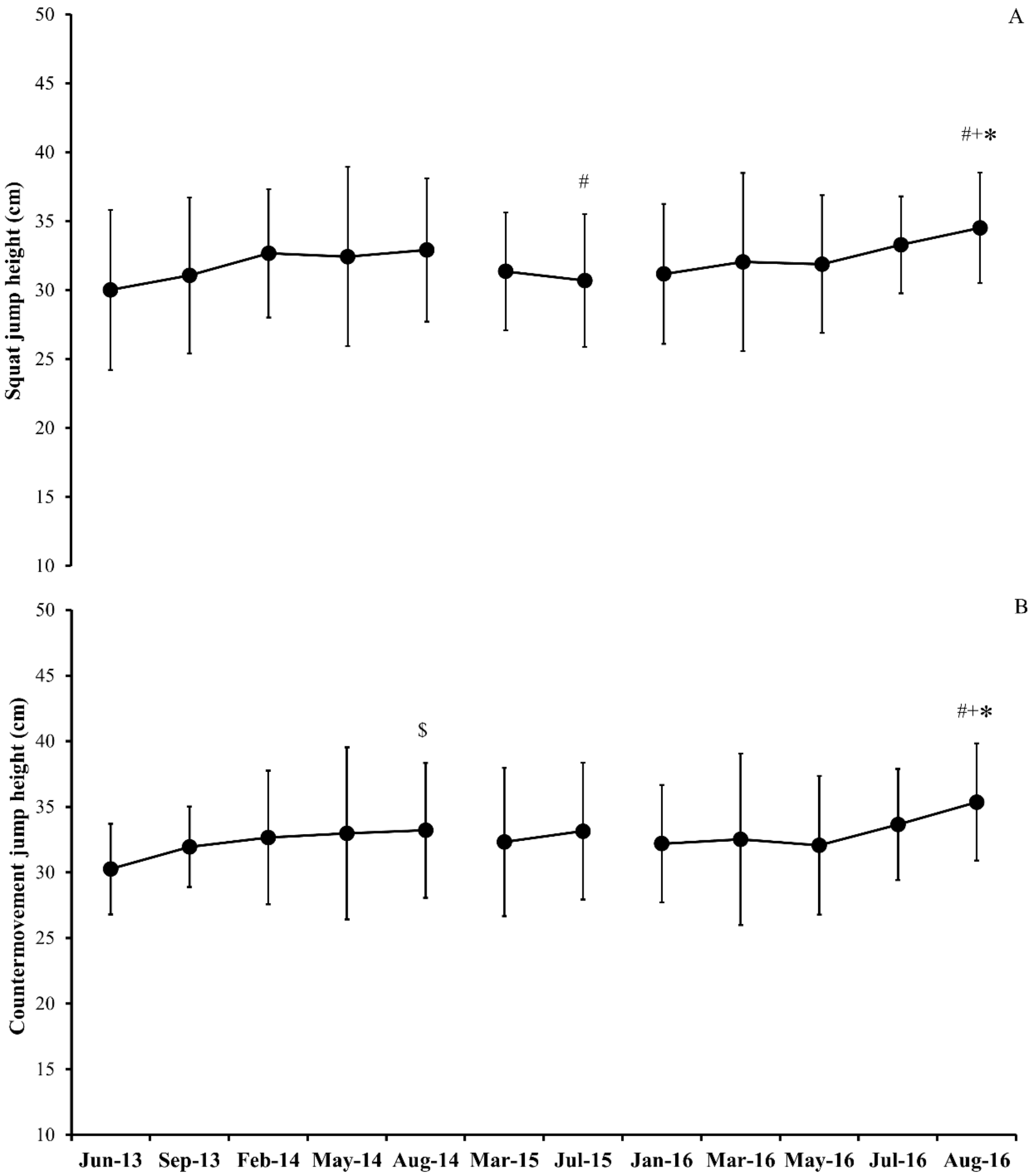

Figure 1

*Vertical jump performances across the different periods of assessments. $Meaningfully (at least likely) different from Jun-13; #meaningfully different from Aug-14 (close to World Championship); + meaningfully different from Jul-15 (close to ParaPan American Games); *meaningfully different from all assessments in 2016 (preparatory period for the Paralympic Games).*

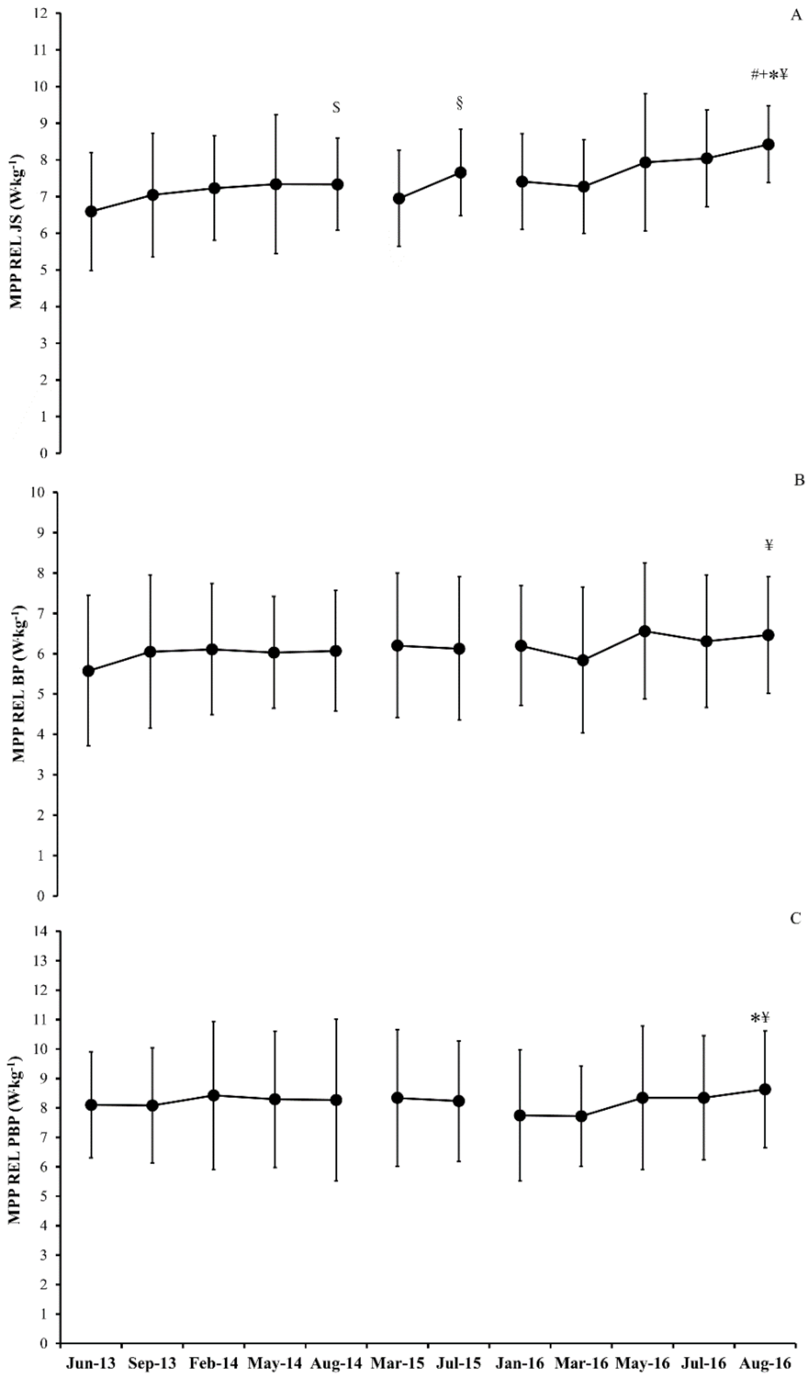

Figure 2

*Comparisons of the mean propulsive power relative to athlete's body mass (MPP REL) in the jump squat (JS), bench press (BP) and prone bench pull (PBP) exercises across the different periods of assessments. [$]Meaningfully (at least likely) different from Jun-13; [§]meaningful different from Mar-15 (preparatory period for ParaPan American Games); [#]meaningfully different from Aug-14 (close to World Championship); [+]meaningfully different from Jul-15 (close to ParaPan American Games); *meaningfully different from Jan-16; [¥]meaningfully different from Mar-16.*

Figure 2 shows the comparisons of the MPP_{REL} in the JS, BP and PBP across the different periods of assessments. The MPP_{REL} JS assessed prior to the World Championship was likely higher than in June 2013 (ES = 0.71). The MPP_{REL} JS was very likely higher in the assessment performed prior to the ParaPan American Games in comparison to March 2015 (ES = 0.58). Prior to participation in the Paralympic Games the MPP_{REL} JS was likely to very likely higher than prior to the World Championship (ES = 0.77) and ParaPan American Games (ES = 0.53), and in January and March 2016 (ES = 0.98 and 0.92, respectively). The MPP_{REL} BP prior to the Paralympic Games was likely higher than in March 2016 (ES = 0.40). Finally, the MPP_{REL} PBP before the Paralympic Games was likely higher than in January and March 2016 (ES = 0.36 and 0.35, respectively).

Discussion

This study aimed to investigate the evolution of physical performance of Paralympic judo athletes throughout a Paralympic Games training cycle (from Jun-13 to Aug-16). The main findings reported herein are: (1) lower-limb power increased gradually throughout the training period, attaining its maximum value immediately before the Paralympic Games; (2) also, in this phase, the judokas produced the greatest power outputs in both BP and PBP exercises; and (3) equally, the best performances in both SJ and CMJ tests were achieved in this period. These results are consistent with previous investigations, which indicated that elite athletes progressively enhance their performance throughout an Olympic preparation cycle, reaching their peak just before the Olympic Games (Plews et al., 2014). Nevertheless, this is the first study to describe this phenomenon in Paralympic athletes.

During the execution of throwing techniques, the judo athletes need to generate high levels of power to move the opponent's body mass and surpass his/her opposing forces (Franchini et al., 2011; Zaggelidis and Lazaridis, 2012). From a biomechanical perspective, this optimal power production is achieved using both lower- and upper-body muscles (Franchini et al., 2013). Thus, the specific improvements observed in jump performance and lower-limb power just before the Paralympic Games can be crucial to increase the probability of success during the powerful hip and knee extensions, which occur in almost all throwing techniques (Franchini et al., 2011; Loturco et al., 2017a; Zaggelidis and Lazaridis, 2012). Also, the worthwhile enhancements noticed in both MPP_{REL} BP and MPP_{REL} PBP may be considered as important factors in optimizing the explosive pushing-pulling actions usually executed during different judo techniques (Franchini et al., 2011; Zaggelidis and Lazaridis, 2012). Considering that the majority of judo scores are obtained via throwing techniques (Miarka et al., 2012), any meaningful change in the physical abilities related to their execution will directly affect judokas' performance (Franchini and Takito, 2014). It is worth mentioning that in Rio-2016 the Brazilian Paralympic Judo Team reached 4 finals, winning 4 silver medals in 13 distinct classes.

Interestingly, throughout the final phase of the Paralympic Games cycle (from Jan-16 to Aug-16) the athletes were under constant supervision of sport scientists. During this period, they performed strength-power training sessions at the optimum power zones (i.e., range of loads where power production is maximized) (Loturco et al., 2016b; Wilson et al., 1993), which is recognized as a very effective strategy to develop the force components at both ends of the force-velocity curve (i.e., low-force/high-velocity and high-force/low-velocity portions) (Loturco et al., 2016a). It has been suggested that this training mode may be superior to conventional training schemes (e.g., traditional strength-training) for enhancing athletic performance (Wilson et al., 1993), especially when power increases are required (Loturco et al., 2016a). Furthermore, the optimum zones always occur at the same bar velocities (Loturco et al., 2016b, 2017b), which highly facilitates monitoring of training, enabling athletes to constantly train with their "updated" loads. It should be emphasized that during this congested fixture period of ~6 months (very close to the Games) these athletes visited the laboratory on five occasions, and were reassessed at their facilities on five more separate times, adjusting the loads whenever necessary. Thus, we can assure that they continually trained under optimal conditions.

Another important point to ponder is the necessity of implementing practical approaches to properly assess these visually-impaired subjects, who all present inherent limitations (Loturco et al., 2017a; Pereira et al., 2016). In this context, the use of more complex and laborious techniques (i.e., maximum dynamic strength assessments) could hamper adequate training progression and reduce subsequent adaptations in neuromechanical capacities over time (Loturco et al., 2016a). If we consider the importance of explosiveness in judo and the possible advantages of gradually reducing the differences in muscle power between Paralympic and Olympic athletes (who are considered as individuals at the extreme ends of human performance) (Loturco et al., 2017a), it becomes reasonable to search for more efficient and applied strength-power training methods. As such, training at the optimum power zones might be a suitable and useful strategy for Paralympic judokas.

We recognize that the lack of training supervision and fine control of loads during the first two cycles (in preparation for the ParaPan American Games and World Championship) is a limitation of the study. However, these periods can be considered the "control" conditions to the cycle prior to the Paralympic Games, allowing us to test the effectiveness of supervised training at the optimum power zones.

Practical Applications

The power performance of Paralympic judo athletes should be constantly evaluated and enhanced throughout different training cycles. The implementation of optimum training zones may highly simplify and improve the work of coaches and sport scientists involved in top-level Paralympic sports.

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