DEVELOPMENT OF AN INDIVIDUALIZED FAMILIARIZATION METHOD FOR VERTICAL JUMPS

ORIGINAL ARTICLE

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ABSTRACT

Objective: The present study was to propose an individualized familiarization method for vertical jumps and to verify its effect on intra-subject variability. Methods: Fifty three men (mean ± S.D.; age 23.5 ± 3.3; height 1.76 ± 0.08 m; mass 72.8 ± 8.6 Kg; body fat 12.9 ± 5.2%) performed successive jumps to reach the proposed stability level. After 48 hours, this process was repeated and the stability between the days was verified; if necessary, more sessions were performed. The stability level was determined by a Z-Test with a confidence interval of 95%. After the familiarization process, two additional experimental sessions were performed in order to determine the reliability of the performance in the Squat Jump (SJ) and the Countermovement Jump (CMJ). The coefficient of variation and standard error of measurement were determined individually (CV_i and SEM_i). A paired T-Test was performed to verify differences in the CV_i and SEM_i before and after the familiarization process. Results: The CV_i presented a significant reduction after the familiarization process ($p < 0.001$), changing from 5.01 ± 2.40% to 2.95 ± 0.89% in the SJ. The CV_i also changed in the CMJ (from 4.50 ± 2.19% to 2.58 ± 0.81%). The same also occurred with the SEM_i in both the SJ and the CMJ, changing from 1.29 ± 0.53 cm to 0.83 ± 0.25 cm in the SJ and from 1.35 ± 0.51cm to 0.83 ± 0.26 cm in the CMJ. Conclusion: The proposed individualized familiarization method significantly decreased intra-subject variability, which allows for a higher statistical power in the laboratorial setting and a greater sensitivity for performance monitoring tools.

Keywords: reliability of results, outcome measurement errors, methodological study, exercise.

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INTRODUCTION

The intra-subject variation is the most important type of reliability measurement for both researchers and coaches[1,2] due to its influence on the identification of significant changes in performance.[3,4] In this regard, the reduction of intra-subject variation is essential for performance evaluation.

The previous execution of a test procedure in order to reduce intra-subject variation is called familiarization, and thus, constitutes an important factor to be considered when testing performance.[5]

Supporting this concept, some studies recommend the usage of familiarization for anaerobic tests in cycle ergometer,[6,7] 1RM testing,[8,9] and vertical jump.[10] However, other studies suggest that familiarization procedures are not necessary prior to sprinting and vertical jumping tests, when utilized to monitor performance.[11-13] The discrepancy between studies may have been motivated by some methodological conditions that may knowingly affect the results, including: (i) the familiarization protocols were different between the studies, with an arbitrarily determined number of jumps and sessions; (ii) as the objective of the familiarization process is to reduce the intra-subject variation, a protocol with a fixed number of sessions and repetitions does not seem ideal, since it does not attend to the specific needs of each individual; (iii) some studies have not performed instability comparisons between pre and post-familiarization scores; (iv) most comparisons took into account only the best jumping performance or the average of a fixed number of the jumps, thus disregarding intra-subject variation; (v) most studies have calculated only group instability which does not accurately represent the type of expected stability after a familiarization process (i.e. the reduction of errors associated to each individual's performance); (vi) some studies present small sample sizes when compared with others evaluating reliability;[14,15] (vii) some studies have utilized the Intraclass correlation coefficient (ICC) as a reliability indicator, whereas Weir[16] suggests that the standard error of measurement (SEM) is a more accurate indicator of reliability.

Therefore, the application of familiarization procedures that respects these methodological conditions could present new information on this individual as it would allow the reduction of errors associated with movement pattern variation and learning effect,[17,18] thus allowing changes in performance to be influenced only by intrinsic variation. Accordingly, Coutts *et al.*[4] have proposed the usage of typical individual variation as a form of intra-subject variation quantification. In fact, the authors suggest that changes in performance superior to the typical individual variation, even if they are not statistically significant, are a worthy implication for the practical application scenario, and hence, should be taken into account by the coach. Finally, in the experimental setting, the reduction of errors associated to a measurement ensures more statistical power[19] and reduces undesired effects in applied research for sports science.[20]

Thus, the aim of the present study was to propose an individualized familiarization method for the vertical jump performance assessment and to verify its effect on the intra-subject variation.

METHODS

Fifty three male participants gave their informed consent to participate (mean ± S.D.; age 23.5 ± 3.3; height 1.76 ± 0.08 m; mass 72.8 ± 8.6 Kg; body fat 12.9 ± 5.2%). All of the participants were recreationally active but not involved in any structured physical training regime and were free from any lower limbs injuries. In order to identify their pre-training status, all of the participants answered the International Physical Activity Questionnaire (IPAQ)[21] (5.0 ± 2.4 hours/week). This study was approved by the ethics committee of the Fumec University. The participants did not engage in any sort of strength training for the lower limbs during the study.

The participants reported to the laboratory for at least four experimental sessions separated by 48 to 72 hours. No strength or power training for the lower limbs was allowed during the completion of the experimental sessions. A standard warm-up specifically designed for vertical jump testing was performed at the beginning of each experimental session.[3] The first two experimental sessions consisted of the proposed familiarization process with the Squat Jump (SJ) and Countermovement Jump (CMJ). When necessary (i.e. jumping performance was not stabilized in the first two days), additional familiarization sessions were performed. The next two experimental sessions, herein designated post-familiarization sessions, were conducted in order to verify the jumping performance reliability.

Height (m) and body mass (Kg) were measured using a scale with a stadiometer (Filizola; São Paulo, Brazil, precision of 0.01 m and 0.1 Kg). Percent fat was calculated by a seven-site skin fold test (triceps brachii, subscapularis, pectoralis major, subaxillary, abdominal, suprailiac and thigh)[22] using a plicometer (Lange; Cambridge, USA, precision of 1 mm).

During the experimental sessions (i.e. the familiarization and post-familiarization sessions), jumping tests included both the SJ and the CMJ. SJ consisted of a maximal concentric action starting from an initial squat position of approximately 90° of knee flexion. CMJ consisted of a maximal concentric action preceded by a fast eccentric action up to approximately 90° of knee flexion. Additionally, an experienced researcher conducted all of the tests and visually checked for countermovement occurrence during the SJ in order to ensure reproducibility. In both vertical jumps, the participants were instructed to keep both knees extended, ankles in plantarflexion and hands on their hips throughout the jump.[23] All of the jumps involved maximum effort and landing was performed with both feet simultaneously touching the ground. In order to avoid external interference on the individual's movement pattern, they were instructed to freely determine the amplitude of the CMJ in order to avoid changes in jumping coordination.[24] Jumps were executed on a contact platform (Jump Test, Hidrofit Ltda; Belo Horizonte, Brazil, precision of 0.1cm), and analyzed with a computer software (Multisprint, Hidrofit Ltda; Belo Horizonte, Brazil).

The proposed familiarization method consisted of at least two familiarization sessions comprised of a minimum of 16 attempts of each jumping technique (i.e. SJ and CMJ) per session with a 1-minute interval between attempts until a stable performance was reached. After the sixteenth jump, a Z-Test was utilized to analyze within-session performance equivalency between the first eight and the last eight jumps (equation 1), considering a confidence interval (CI) of 95%.[25] Whenever jumping stability was not reached within the 16 pre-determined jumps, additional attempts were allowed. In this case, the Z-Test considered the last 16 jumps performed (divided into two 8-jump blocks) for analysis. The familiarization session was interrupted whenever stability was reached. Additionally, the familiarization session was also interrupted in case the participant presented a significant reduction in performance between the first eight and the last eight jumps (as assessed by a paired t-test between the first eight and the last eight jumps).

$$Z = \frac{(M_1 - M_2) - \delta_1}{\sqrt{\left[\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}\right]\left[\frac{1}{n_1} + \frac{1}{n_2}\right]}}$$

M_1 bigger mean, M_2 smaller mean δ_1 5% of M_1

The second familiarization session was performed after a 48 to 72 hour interval, in the same fashion as described above. The between-session equivalency was verified with a Z-Test comparing the performance of the last 16 jumps of each day. Importantly, if either the within- or the between-session performance was not stable, a new session was held.

The number of jumps used to evaluate the instability of the vertical jump performance was previously determined by equation derived from a t-test. Fo/78/4r that, a pilot study in which 84 individuals performed 6 to 10 jumps was conducted.

The post-familiarization sessions were conducted after a 48- to 72-hour interval from the last familiarization session. A similar interval was allowed between post-familiarization sessions. In each session, after a standardized warm-up procedure,[3] eight jumps of each jumping technique (i.e. SJ and CMJ) were performed. Thus, it was possible to evaluate the within- and the between-session performance variation.

Data normality and equal variances were verified by using the Kolmogorov-Smirnov and the Levene tests, respectively. To measure the instability of each individual's performance, the coefficient of variation (CV_i) was calculated by dividing the standard deviation by the mean of the first eight jumps of the first familiarization session and the first eight jumps of the first post-familiarization session.

Additionally, the individual standard error of measurement (SEM_i) was calculated by the square root of the mean square of the error, obtained through a two-way ANOVA procedure for each individual, assuming trials and testing sessions as the two factors. Importantly, the SEM_s calculations were based on the first eight jumps of each experimental session (two familiarization sessions and two post-familiarization sessions). The within-session and the within-between sessions coefficient of variation for the whole group ($CV_{g\,1.1}$ and $CV_{g3.1}$, respectively; n=53) were calculated as the square root of the error mean square (obtained through a one-way ANOVA for repeated measures and a two-way ANOVA for repeated measures respectively) divided by the group mean. The standard error of the measurement for the whole group was calculated as the square root of the mean square of the error (obtained either through a one-way ANOVA for repeated measures, $SEM_{g\ 1.1}$, n=53 or through a two-way ANOVA for repeated measures, $SEM_{g\ 3.1}$, n=53) times $t_{95,52}$.

Intraclass correlation coefficient (ICC) was also calculated within- (1.1) and within-between sessions (3.1) as previously described.[16] These variables were utilized as relative (ICC) and absolute (CV_g and SEM_g) indicators of group reliability.[16]

A paired t-test was performed to compare both the CV_i and the SEM_i before and after the familiarization process. Effect size (ES) for both the CV_i and the SEM_i was calculated according to the previous description.[26] When necessary, an angular transformation was utilized for CV_i and SEM_i data according to the previous description.[27] This transformation calculates the arcsine of the square root of the measurement. Inferential and/or descriptive analyzes were performed. Statistical analyses were performed in Sigma Stat 3.5 (Systat Software; San Jose, USA) and Microsoft Office Excel 2003 (Microsoft; Redmond, USA) softwares. The significance level was set at $p \leq 0.05$.

RESULTS

The familiarization process resulted in significantly smaller CV_s and SEM_s for both the SJ and CMJ (table 1).

Regarding the within-session reliability indicators, an increased ICC (1.1) for both the SJ and the CMJ at post-familiarization (POST) were observed when compared with the familiarization session (PRE) (SJ: PRE = 0.82 and POST = 0.95; CMJ: PRE = 0.79 and POST = 0.97). $CV_{g\ 1.1}$ for both the SJ and CMJ was reduced after the familiarization process (SJ: PRE = 5.34% and POST = 2.96%; CMJ: PRE = 4.80% and POST = 2.65%). Similarly, the $SEM_{g1.1}$ was lower at the post-familiarization sessions when compared to familiarization sessions for both the SJ and the CMJ (SJ: PRE = 3.15 cm and POST = 1.81 cm; CMJ: PRE = 3.16 cm and POST = 1.83 cm).

Table 1. Data of instability, pre and post-familiarization sessions.

	CVi (%)		SEMi (cm)	
	SJ	CMJ	SJ	CMJ
PRE	5.01 ± 2.40	4.5 ± 2.19	1.29 ± 0.53	1.35 ± 0.51
POST	2.95 ± 0.89	2.58 ± 0.81	0.83 ± 0.25	0.83 ± 0.26
p	< 0.001	< 0.001	< 0.001	< 0.001
ES	1.14	1.16	1.06	1.29

CMJ = countermovement jump; VCi = Individualized Coefficient of Variation ; ES = effect size; SEMi = individual standard error of measurement; SJ = squat jump.

The within-between sessions ICC (3.1) analysis showed improved reliability for both jumping techniques after familiarization (SJ: PRE = 0.87 and POST = 0.96; CMJ: PRE = 0.92 and POST = 0.98). The $CV_{g\ 3.1}$ for the SJ and the CMJ were lower after familiarization (SJ: PRE = 4.73% and POST = 2.96%; CMJ: PRE = 4.34% and POST = 2.51%). Similarly, the $SEM_{g\ 3.1}$ values were lower after the familiarization process (SJ: PRE = 2.74 cm and POST = 1.77 cm; CMJ: PRE = 2.82 cm and POST = 1.69 cm). Figure 1 presents each individual SEM_i value, mean and CI (95%) for both the SJ and the CMJ.

DISCUSSION

The main finding of the present study was that the proposed familiarization method significantly reduced CV_i and SEM_i for both the SJ and the CMJ. Importantly, the $CV_{g1.1/3.1}$ and $SEM_{g1.1/3.1}$ were also reduced. The CV and SEM are dispersion measurements that evaluate the total instability degree of a measurement[5] and the magnitude of the random errors, respectively.[16]

Training response may be evaluated by the minimum clinically-

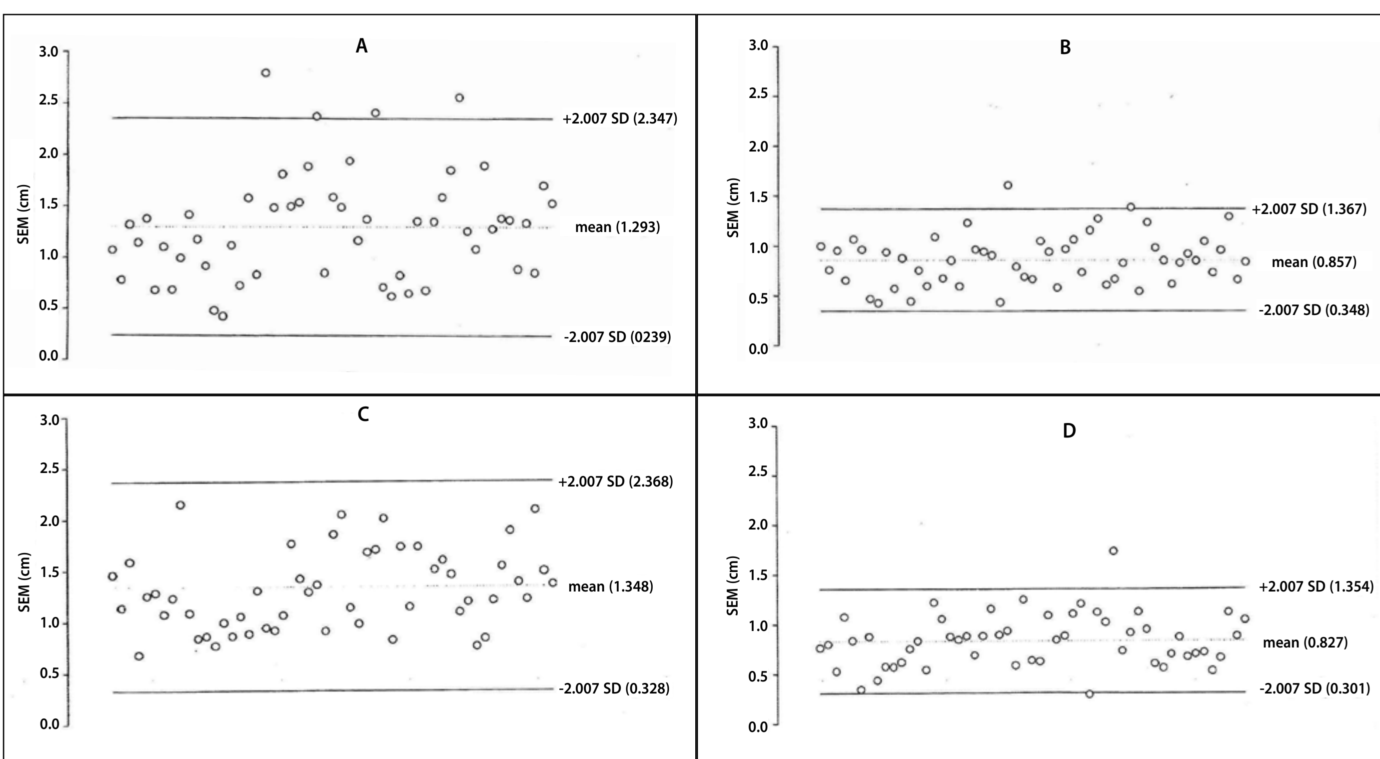

Figure 1. Plotted SEMi pre and post-familiarization sessions with vertical jumps. Figure A: PRE SJ; Figure B: POST SJ; Figure C: PRE CMJ; Figure D: POST CMJ. CMJ = countermovement jump; POST = post-familiarization session; PRE = pre-familiarization session; SEMi = individual standard error of measurement; SJ = squat jump.

important difference (MCID)[4] and the minimal individual difference (MID).[3] The SEM is used as a basis for the calculation of these variables[16,28]. Thus, the reduction of the SEM, as observed in this study, implies a reduction of the value of these variables, thereby increasing their sensitivity.

In this regard, Coutts *et al*.[4] used the MCID to evaluate the vertical jump performance (among other variables) after an overreaching and tapering protocol. Although no significant differences in vertical jump performance were identified, it changed above the MCID, leading the authors to suggest that the alterations above the MCID may have practical importance in sports training.

Supporting this concept, Claudino *et al*.[3] utilized another variable that quantifies intra-subject variation, i.e., the minimal difference. This variable was calculated as suggested by Weir,[16] however, the authors individually determined the typical variation and calculated the CI according to the sample's degrees of freedom. Claudino *et al*.[3] termed this variable as the minimal individual difference (MID). By using the MID as a tool for monitoring and regulating the training load, the authors were able to reduce the plyometric training volume without affecting performance. Collectively, Coutts *et al*.[4] and Claudino *et al*.[3] have demonstrated the efficiency of the SEM in monitoring the training load and assessing training-induced changes in performance.

In order to evaluate the influence of the proposed familiarization method in the experimental setting, the statistical power of an ANOVA test was calculated by using the Markovic[29] meta-analysis data and the familiarization and post-familiarization sessions results from the present study. Assuming a change in the SJ performance of 4.7% (CI 95% = 1.8% - 7.6%),[29] a statistical power of 0.61 (non--familiarized) and 0.95 (familiarized) was found. The statistical power for the inferior and superior limits of the CI were also calculated. The power values were 0.13 (non-familiarized) and 0.25 (familiarized), and 0.96 (non-familiarized) and 1.00 (familiarized), at the inferior and superior CI limits, respectively. Therefore, the power always increased after the familiarization procedure in the present study. One may argue that in situations where the magnitude of the change in performance is big (as in the data above), the influence of the familiarization process in the statistical power may be rather small. This may have happened due to the already large statistical power obtained by the non-familiarized individuals (0.96). However, even in this case, the increase in power due to familiarization, would allow the observation of significant differences in a shorter period of intervention or with a smaller sample size.

Therefore, although some studies did not find the familiarization process necessary,[11-13] our results demonstrate that the proposed familiarization method may be beneficial not only at the practical field, but also, at the research setting. In fact, our data is in agreement with previous research suggesting the need for a familiarization process prior to performance testing as considered before. Importantly, most studies have used the ICC for instability assessments; however, such approach may not be suitable when addressing the individual's instability. Despite the fact that both the ICC and the CV_g/SEM_g values indicate increased group stability, this may not be extrapolated to the individual. The present study addressed the issue of familiarization with a different experimental design, emphasizing the relevance of the alterations produced by the familiarization method instead of merely evaluating the test instability. The advantage of this method is the possibility of individualization, which guarantees that by the end of the familiarization, all of the participants will have attained the desired degree of stabilization. Methods with a pre-defined number of sessions and trials will naturally produce different effects on different individuals, thus not producing satisfactory individual results. These methodological differences do not allow a comparison between our results and other studies found in the literature.

CONCLUSION

In conclusion, the proposed individualized familiarization method significantly reduced the intra-subject variation. This error reduction guarantees a higher statistical power for experimental studies and greater sensitivity for performance monitoring tools.

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REFERENCES

1. Atkinson G, Nevill AM. Statistical methods for assessing measurement error (reliability) in variables relevant to Sports Medicine. Sports Med 1998;26:217-38.
2. Hopkins WG. Measures of reliability in sports medicine and science. Sports Med 2000;30:1-15.
3. Claudino JG, Mezêncio B, Soncin R, Ferreira JC, Couto BP, Szmuchrowski LA. Pre vertical jump performance to regulate the training volume. Int J Sports Med 2012;33:101-7.
4. Coutts A, Reaburn P, Piva TJ, Murphy A. Changes in selected biochemical, muscular strength, power, and endurance measures during deliberate overreaching and tapering in rugby league players. Int J Sports Med 2007;28:116-24.
5. Currell K, Jeukendrup AE. Validity, reliability and sensitivity of measures of sporting performance. Sports Med 2008;38:297-316.
6. Mendez-Villanueva A, Bishop D, Hamer P. Reproducibility of a 6-s maximal cycling sprint test. J Sci Med Sport 2007;10(5):323-6.
7. Martin JC, Diedrich D, Coyle EF. Time course of learning to produce maximum cycling power. Int J Sports Med 2000;21:485-7.
8. Taylor JD, Fletcher JP. Reliability of the 8-repetition maximum test in men and women. J Sci Med Sport 2012;15:69-73.
9. Levinger I, Goodman C, Hare DL, Jerums G, Toia D, Selig S. The reliability of the 1RM test for untrained middle-aged individuals. J Sci Med Sport 2009;12:310-6.
10. Arteaga R, Dorado C, Chavarren J, Calbet JAL. Reliability of jumping performance in active men and women under different stretch loading conditions. J Sports Med Phys Fitness 2000;40:26-34.
11. Glaister M, Howatson G, Lockey RA, Abraham CS, Goodwin JE, McInnes G. Familiarization and reliability of multiple sprint running performance indices. J Strength Cond Res 2007;21:857-9.
12. Moir G, Sanders R, Button C, Glaister M. The influence of familiarization on the reliability of force variables measured during unloaded and loaded vertical jumps. J Strength Cond Res 2005;19:140-5.
13. Moir G, Button C, Glaister M, Stone MH. Influence of familiarization on the reliability of vertical jump and acceleration sprinting performance in physical active men. J Strength Cond Res 2004;18:276-80.
14. Markovic G, Dizdar D, Jukic I, Cardinale M. Reliability and factorial validity of squat and countermovement jump tests. J Strength Cond Res 2004;18:551-5.
15. Slinde F, Suber C, Suber L, Edwén CE, Svantesson U. Test-retest reliability of three different countermovement jumping test. J Strength Cond Res 2008;22:640-4.
16. Weir JP. Quantifying test-retest reliability using ICC and the SEM. J Strength Cond Res 2005;19:231-40.
17. Schmidt R, Wrisberg C. Motor learning and performance: a situation-based learning approach. 4th ed. Champaign (IL): Human Kinetics; 2008.
18. Wulf G, Shea CH. Principles derived from the study of simple skills do not generalize to complex skill learning. Psychon Bull Rev 2002;9:185-211.
19. Hopkins WG, Schabort EJ, Hawley JA. Reliability of power in physical performance tests. Sports Med 2001;31:211-34.
20. Bishop D. An applied research model for the sport sciences. Sports Med 2008;38:253-63.
21. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, *et al*. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc 2003;35:1381-95.
22. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. Br J Nutr 1978;40:497-504.
23. Herrero JA, Izquierdo M, Maffiuletti NA, Garcia-López J. Electromyostimulation and plyometric training effects on jumping and sprint time. Int J Sports Med 2006;27:533-9.
24. Ugrinowitsch C, Tricoli V, Rodacki AL, Batista M, Ricard MD. Influence of training background on jumping height. J Strength Cond Res 2007;21:848-52.
25. Rogers JL, Howard KI, Vessey JT. Using significance tests to evaluate equivalence between two experimental groups. Psychol Bull 1993;113:553-65.
26. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. Hillsdale (NJ): Lawrence Erlbaum, 1988.
27. Cook JR, Heyse JF. Use of an angular transformation for ratio estimation in cost-effectiveness analysis. Stat Med 2000;19:2989-3003.
28. Hopkins WG. How to interpret changes in an athletic performance test. Sport Sci 2004;8:1-7.
29. Markovic G. Does plyometric training improve vertical jump height? A meta-analytical review. Br J Sports Med 2007;41:349-55.