2006

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Publication details

Coutts, RA, Gilleard, WL, Hennessy, M, Silk, A, Williams, G & Weatherby, RP 2006, 'Development and assessment of an incremental fatigue protocol for contemporary dance', *Medical Problems of Performing Artists*, vol. 21, no. 2, pp. 65-70.
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Development and Assessment of an Incremental Fatigue Protocol for Contemporary Dance

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Abstract—Nine trained contemporary dancers performed a modality-specific, heart-rate-monitored, choreographed fatiguing dance protocol with an assumption of fatigue at volitional exhaustion (RPE 16). Postural stability was assessed as the variability of ground reaction forces and the centre of pressure during the performance of a flat-foot arabesque. Psychological response was assessed using self-reported fatigue, psychological distress (PD), and psychological well-being (PWB) (Subjective Exercise Experience Scale). After reaching RPE 16 in 15.7 ± 2.6 mins, heart rate decreased to the post-warm-up level within 64 ± 9 sec. Variability of ground reaction forces or the centre of pressure was not changed. There were no significant changes in fatigue, psychological distress, or psychological well-being. Within fatigue, there was a significant increase in the item tired ($p = 0.04$). As supported by the heart rate data and RPE, the protocol achieved an appropriate level of physical demand. No changes in the stability indices were observed, possibly attributed to the rapid recovery in heart rate. The expression of only tiredness suggests the use of a disassociative attentional style by the dancers. The project represents pilot work toward the validation of a monitoring process that supports dancer health and awareness training. *Med Probl Perform Art* 2006;21:65–70.

Within Australia, contemporary dancers represent 23% of practising professional dancers. These performers are finely tuned athletes, investing many hours in perfecting fitness and ability. Like most dancers, they begin their careers at an early age, reaching professional status by a median age of 23 years, younger than any other artist excluding musicians.[1] Former dancers nominated "health issues/effect of injuries" as the second highest reason for their career termination, with current practising dancers stating this as their foremost worry.[2] Dancers also acknowledge that training is the most important factor in the advancement or inhibition of their career.[1] In general, evidence supports the existence, even at a young age, of long working hours, repetitive and relentless schedules, and pressure to perform at a peak level often despite the presence of fatigue and injury.

At the elite level, contemporary dancers demonstrate their own unique stresses.[3] The intense and continued focus on prowess and beauty, the need to be thin, and the ability to tolerate high levels of pain often contribute toward severe levels of occupational stress.[4-6] As physical training for fitness and skill in dance is similar to that experienced by athletes,[7,8] an improper program can, if not recognised, result in overtraining, injuries, and decreased performance.[9,10] It is important therefore that dancers' fitness levels are monitored as a component of their training program.

Athletic fitness is typically assessed using fatiguing protocols that are incremental in design and devised within standard laboratory settings, utilising cycle ergometers or treadmills. Because training regimes are sport specific,[9] assessment protocols can be constructed to mirror specificity also. Protocols specific to the assessment of dancers have not yet been developed. Any such assessment protocol developed for contemporary dancers should reflect not only the intensity but also the specific movement demands (including both upper and lower limb activity) and the appropriate elements of musicality. It is also suggested that protocols be constructed not only to reflect industry specificity, but also to be conducted easily by instructors and dancers within their own particular settings. This preliminary investigation explored a novel dance-specific protocol in a multidimensional manner.

Cardiorespiratory fitness is an important factor in athletic performance and is related to the ability to perform dynamic, moderate to high intensity exercise for prolonged periods of time.[11] An athlete's level of cardiorespiratory fitness is dependent on the combined functional state of the cardiovascular, respiratory, and skeletal muscle systems.[12] The criterion measure when assessing athletic cardiorespiratory fitness is maximal oxygen uptake (VO_{2max}) and is generally tested with an incremental ergometer-based protocol to exercise the athlete to volitional exhaustion. Testing in this manner

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Funding for this work was provided from an ARC-Linkage grant LP 0348068 to Professor Paul Thom (FAHA), Executive Dean of Arts, Southern Cross University. The authors are grateful for the expertise and advice provided by Dr. Sonya Marshall-Gradisnik during the experimental preparation and testing sessions, and for research assistance from Sarah Sinclair-Ross, Dianne Swift, and Robert T Weatherby, Jr.

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TABLE 1. Characteristics of the Nine Contemporary Dancers *

	Mean ± SD
Age (yrs)	18.8 ± 5.1
Gender	3 male, 6 female
Mass (kg)	57.5 ± 5.1
Height (m)	1.70 ± 0.06
BMI (kg/m^2)	20.0 ± 2.2

* Data expressed as mean ± SD where appropriate.

directly measures the body's ability to use oxygen during exercise. The more effectively and efficiently the body is able to utilise oxygen, the easier it will be for an athlete to perform exercise at a set intensity, and therefore exercise can be tolerated for a longer period of time prior to fatigue.[12] However, laboratory-based VO_{2max} testing is time consuming and requires the collection of expired gases, the use of expensive equipment, and appropriately trained personnel. In addition, the testing protocols that are currently available are not specific to the demands of contemporary dance.

Muscular fatigue may affect the ability to generate enough force to perform movements and maintain stability[13] and also may cause a change in postural control strategy.[14] Held postures such as arabesques, where balance control is essential, are common in dance. Fatigue effects on balance control in dancers, however, are unknown, although fatigue is thought to be a primary contributor to chronic foot and ankle injuries.[15]

Fatigue is multifactorial, reflecting both the physical and psychological.[13] Of considerable importance is the well-being of dance participants. During intense physical demand, some athletes will disassociate themselves when experiencing performance pain and discomfort by focusing elsewhere, with the result being increased susceptibility to injury. Other athletes employ a more associative style, monitoring their body signals and making adjustments to maintain efficiency.[16] The attentional style used by dancers is not yet known.

The present study explored the multidimensional effects of a novel incremental fatigue protocol for contemporary dancers using physiological, psychological, and postural stability indices. The physiological index measured was heart rate (HR), expressed as percentage of age-predicted maximum heart rate ($\%HR_{max}$). Stability indices to investigate postural control were the variability measures of anteroposterior and mediolateral ground reaction forces (GRF) and the path of the centre of pressure (CoP) during the performance of an arabesque. Psychological effect was assessed using self-report, relating the dancer's perception of the physical demand, expressed as fatigue, psychological well-being, distress, and soreness.

METHODS

Nine trained (Grade 5 and above) contemporary dance students, who were recruited from the Northern Rivers Conservatorium and regional dance schools, voluntarily participated in the project. Details of the participants are shown in Table 1. The research was approved by the Southern Cross University Human Research Ethics Committee (approval no. ECN-04-176). The volunteers read participant information sheets, and informed consents were completed, including parental approval for those under 18 years of age. Medical screening procedures were then performed.

Pre-Performance of the Experimental Protocol

Under the guidance of a trained professional dance instructor and prior to the study's commencement, each dancer was required to learn a choreographed combination that was to be performed during the dance protocol. Each dancer also was familiarized with the Rate of Perceived Exertion (RPE) scale.[17] Participants were instructed to refrain from strenuous physical exercise 24 hours prior to testing.

Experimental Protocol

Height, body mass, right foot width, and right foot breadth were measured, and dancers fitted with a heart rate monitor (Polar® Model S610, Vantaa, Finland). Dancers then responded to the Subjective Exercise Experience Scale (SEES) questionnaire and rated their muscle soreness. A warm-up consisting of 3 minutes of low-intensity (60 W @ 60 rpm) cycling (Monark 868, Varberg, Sweden and 2 minutes of static stretching followed. As a test of postural stability, dancers then performed five trials of a right-leg flat-foot arabesque on a force plate (Kistler, Type 9287).

The fatiguing dance protocol was then performed. Immediately following the incremental fatiguing dance protocol, each dancer responded again to the SEES questionnaire, rated their muscle soreness, and performed another five trials of the arabesque. The dancers completed each testing session individually.

Incremental Fatiguing Dance Protocol

Supported by music, the incremental fatiguing dance protocol was conducted by a trained dance instructor. The routine was incremental, designed to be dance specific and to encourage maximum response from the cardiorespiratory and musculoskeletal systems. The protocol comprised four components:

- 6-Minute general low-to-medium intensity warm-up consisting of basic dance movements (*plies, tendus, glisses, rond de jambe*, and set contemporary sequences).
- Two lots of 3-minute blocks of increasing intensity dance—these 3-minute blocks were conducted as progressions from the diagonal and were designed to steadily increase the physiological workload experienced by the dancers. Dancers were required to move quickly from one exercise to the next in order to maintain the required intensity.
- Pre-learnt and rehearsed choreographed combination that was reflective of performance intensity, musicality, and movements. The combination was consistently performed at a high energy level. The combination lasted for approximately 2 minutes and was designed so that it could be repeated as necessary until dancers reported an RPE 16.

RPE and Heart Rate

The Borg 6-20 category scale was visible to dancers so as to assess their perception at various time points during the dance protocol. RPE was requested following the 6-minute dance warm-up, after each of the two subsequent 3-minute blocks, and then at the completion of each pre-rehearsed choreographed combination. The fatiguing dance protocol ceased when the dancer reported RPE 16.

Heart rate at rest and at the completion of the cycle ergometer warm-up was noted. Heart rate was recorded at 5-second intervals throughout the data collection. Raw heart rate data were converted to the percentage of the subject's predicted maximal heart rate ($\%HR_{max}$), using the 220 – age equation, before being analysed. Heart rate at six separate time points was compared: (1) after the cycle ergometer warm-up, (2) at the completion of the 6-minute general warm-up of the dance protocol, (3) at RPE 16, (4) at the commencement of and (5) during the post-dance postural stability data collection, and (6) at 10 minutes after cessation of the dance protocol.

Following assessment of normality of distribution using Shapiro-Wilks and boxplots, a repeated measures analysis of variance (RM-ANOVA) with differences contrasts was used to investigate differences between successive time points (SPSS 11.5). The α level of significance was set at $p < 0.05$.

Postural Stability

Each dancer completed five successful right-leg flat-foot held arabesques on an embedded force plate sampling at 100 Hz. A trial was considered successful if according to the researcher's verbal cues, the participant stepped into the arabesque, held for 5 seconds, and then stepped down from the arabesque. Force data were divided by body weight, and the centre of pressure in the anterior-posterior direction (CoPant-post) and centre of pressure in the medial-lateral direction (CoPmed-lat) data was divided by foot length and breadth, respectively, in order to account for mass and foot size differences between the subjects.

Percentage of instability in the vertical direction of the GRF (GRFvertical) was used as a criterion to determine the time of onset of the held arabesque. The percentage of instability was calculated as (1 GRFvertical – Actual GRFvertical) multiplied by 100, with score of 1 GRFvertical representing a completely steady subject. The held component of the arabesque was defined as commencing when the percentage of instability in the vertical direction was less than 10%.

For the stability indices, the standard deviation for anterior-posterior and medio-lateral GRF and GP (GRFant-post, GRFmed-lat, CoPant-post, and CoPmed-lat) was then calculated for each arabesque held component for the subsequent 3 seconds of trial data. Shapiro-Wilks tests of normality and boxplots showed only six out of eight stability indices were normally distributed and therefore a nonparametric approach would normally be used. As there were multiple repeated measures and a trend analysis was required, a nonparametric approach, however, would not have allowed a priori testing for multiple variables and contrasts. A repeated measures MANOVA (Wilks' λ criterion) was used to investigate differences between the pre- and post-incremental fatiguing protocol with within-subjects contrasts to investigate the existence of linear trends across the five trials for each stability index (SPSS 11.5). Significance (two-tailed) was accepted at $p < 0.05$. Due to some violation of parametric testing assumptions care must be taken with any significant findings for the stability indices.

Psychological Response

The SEES as a brief and sensitive global measure[18] was used to assess response to the incremental fatiguing dance protocol. It was able to support a dynamic and dimensional approach to the assessment of both physical and psychological fatigue of the dancer before and after the protocol.

The instrument measures 12 items, which when combined into dimensions represent global psychological responses, both positive and negative. The items combine into three factor-analysis supported dimensions: fatigue, psychological distress (PD), and positive well-being (PWB).[18] The instrument is not a measure of the immediate emotion, but rather a measure of the response from which emotions are expressed. Each dancer rated their response to the individual emotion words of the SEES (Likert scale of 1 to 7). In addition, dancers were also asked to rate their muscular soreness on a scale of 0 to 10, immediately before and after the fatiguing protocol. A researcher verbally spoke each item to the participants asking them to indicate their immediate response. Each dancer was encouraged to limit his or her judgments to only their immediate personal reaction (i.e., not other surrounding influences, the instructor, or researchers).

The 12 items of the SEES were each allocated to pre- and post-dimensions of fatigue, PD, or PWB. Because the questionnaire data were ordinal, a Wilcoxon signed rank test was conducted to compare the pre- and post-scores (SPSS 11.5), and significance (2-tailed) was accepted at $p < 0.05$.

RESULTS

Cardiovascular Response

Each successive time point was significantly different from the one that preceded it (with-in subjects contrasts $p < 0.01$), as shown in Table 2. The mean exercise time to RPE 16 was 15.7 ± 2.6 minutes, with a peak $\%HR_{max}$ of 95.2 ± 4.1. Within the time taken to respond to the post-exercise psychological questionnaires (64 ± 9 sec), there was a rapid heart rate decrease, as seen in Figure 1. From the other possible pairwise comparisons, $\%HR_{max}$ after the completion of the 6-minute general dance warm-up (time point 2) was not significantly different from the $\%HR_{max}$ at the start of post-dance protocol postural stability data collection (time point 4) (pairwise comparisons $p = 0.643$).

TABLE 2. Cardiovascular Responses at Various Time Points in the Incremental Fatiguing Dance Protocol

Time Point	Description	$\%HR_{max}$*	Comparison†	*F* Value	*p* Value
1	Completion of cycle ergo warm-up	61.1 ± 5.1	N/A	N/A	N/A
2	End of 6-minute general dance warm-up	77.2 ± 7.9	1 vs 2	43.37	< 0.001
3	At RPE 16	95.2 ± 4.1	2 vs 3	84.03	< 0.001
4	Before post-dance stability data collection	78.1 ± 7.1	3 vs 4	66.82	< 0.001
5	During stability data collection	70.5 ± 5.5	4 vs 5	22.33	< 0.01
6	End of 10-min recovery	50.6 ± 4.6	5 vs 6	182.86	< 0.001

*Data expressed are mean ± SD of percentage of predicted maximum heart rate ($\%HR_{max}$).
†Comparisons are from repeated measures ANOVA – within subjects contrast. $p < 0.05$ denotes significance.

Stability Indices

The pre- and post-fatigue mean, univariate (Huynh-Feldt), and within-subjects linear contrasts for GRFant-post, GRFmed-lat, CoPant-post, and CoPmed-lat are presented in Table 3. The multivariate *F* value of 1.87 was not significant at $p = 0.254$, and there were no significant linear trends that would indicate a consistent direction of change in postural stability over the five trials.

Psychological Response

There were no significant differences observed for the dimensions of PWB ($p = 0.53$), PD ($p = 1.00$), or fatigue ($p = 0.09$), as shown in Table 4. For the individual items, there was one significant difference for tiredness ($p = 0.04$). The dance protocol had been challenging enough to elicit tiredness in the dancers; however, it had not elicited a global fatigue state (combined scores for exhausted, fatigued, tired, and drained). There was a small increase in the dancers' perception of their muscular soreness (3.00 ± 3.08) before the fatiguing dance routine when compared to post-routine (3.06 ± 1.88); however, this difference was not significant ($p = 0.495$).

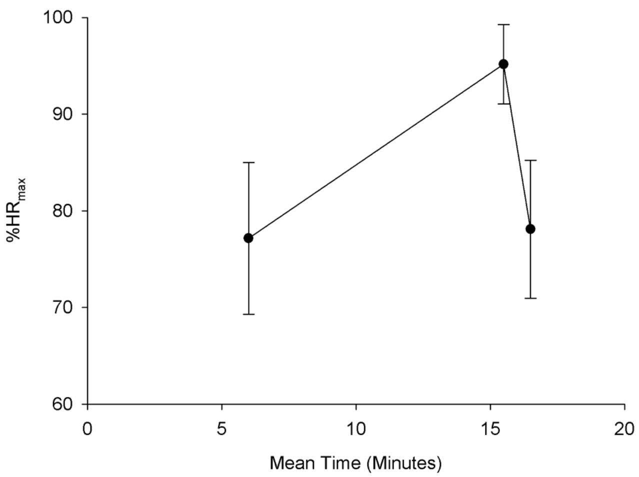

FIGURE 1. Percentage of predicted HR_{max} at three time points during the incremental fatiguing protocol: at the completion of the 6-min general dance warm-up (time point 2), at RPE 16 (time point 3), and at the start of the post-dance protocol stability data collection (time point 4).

DISCUSSION

This study sought to use a dance-specific, incrementally fatiguing protocol with a group of trained contemporary dancers to investigate its usefulness for fitness assessment and the monitoring of training and performance effects. The constructed protocol contained the considered elements of both musicality and athletic criteria.

The fatiguing dance protocol elicited the rate of perceived exertion of 16 (RPE 16) and was able to be reached within an average duration of 16 minutes. The hard-very hard exertion (RPE 16) that was reached by the dancers was supported by their attaining an average peak of 95.2% of predicted maximum heart rate, indicating significant changes in cardiovascular response as a result of the incremental workload. Changes in the individual heart rate scores were consistent within individual response and were similar to the response to exercise that would be expected from an athletic population.[11,12]

The stability indices found, indicate that arabesques are inherently unstable postures (shown in Table 3). The variability of the centre of pressure (CoP) in both ant-post and med-lat directions was considerably higher both before and after the fatiguing dance protocol than Ageberg et al.[14] reported for one-leg standing, indicating the held posture of an arabesque is inherently less stable than standing on one leg. The arabesque stability, however, was generally better than that reported for handstands,[19] although as vestibular systems provide a larger contribution to balance, it is not surprising that an inverted posture such as a handstand is less stable than a more upright posture such as arabesque.

The incremental fatigue protocol did not significantly affect postural stability during an arabesque. As balance control is multifactorial, it is possible that lower-extremity muscle strength is not the dominant factor in maintaining balance.[20] For example, visual stimuli may be able to compensate for fatigue.[21] Dancers tend to use spatial landmarks to facilitate their balance,[22] and as dancers display a more flexible behavioral control,[23] they may have been able to rapidly compensate for the effects of the fatigue using visual contributions.

TABLE 3. Pre- and Post-Fatigue Values, Univariate (Huynh-Feldt), and Within-Subjects Linear Contrasts for Stability Indices of Ground Reaction Force and Centre of Pressure

Ratio	Pre-Fatigue Protocol*	Post-Fatigue Protocol*	$F_{Huynh\text{-}Feldt}$	p Value	F_{linear}	p Value
GRFant-post variability	0.017 ± 0.003	0.015 ± 0.006	0.33	0.58	5.38	0.05
GRFmed-lat variability	0.011 ± 0.002	0.011 ± 0.001	2.32	0.17	0.301	0.19
CoPant-post variability	0.050 ± 0.008	0.063 ± 0.031	1.64	0.24	2.78	0.20
CoPmed-lat variability	0.103 ± 0.030	0.128 ± 0.044	3.74	0.09	2.02	0.26

*Data expressed as mean ± SD. $p < 0.05$ denotes significance.

The significant decrease in stability that Ageberg et al.[14] reported for a one-leg stance after a generalised fatigue protocol was very small. As an arabesque appears inherently more unstable, then small differences in stability with fatigue may not be of sufficient magnitude to reach statistical significance. Evidence for this effect is seen in CoP medio-lateral stability (Table 3), where the relatively large variability indicated by the standard deviation may have precluded the possibility of a significant difference. The posture used to assess fatigue effects on postural stability in contemporary dancers requires further investigation.

It is also possible that the lack of change in balance control may have resulted from rapid recovery occurring while the post-dance protocol SEES was being administered. The heart rate values reflect this possibility, with the sharp decrease observed in $\%HR_{max}$ at the start of the post-dance stability data collection point not being significantly different from the $\%HR_{max}$ after the 6-minute general dance warm-up (Figure 1). This recovery appears to have been substantially complete in the 64 ± 9-second time interval prior to stability testing and reflects that experienced contemporary dancers have short recovery times not unlike elite athletes.[12] Further research should aim to collect the stability measures prior to the recovery.

Apart from their tiredness, there were no real changes in the acute expressions of how the dancers felt immediately after their physical effort. Toward the end of the fatigue protocol, researchers anecdotally observed lower-limb postural changes which would indicate fatigue, with a potential for injury, as the dancers approached RPE 16. Additionally, dancers were observed to be using active recovering techniques following the protocol. Therefore, the use of professional assessment of dance postures during the fatiguing dance protocol and monitoring the use of active recovery techniques is recommended for future research.

We are confident that the protocol had been physically demanding, as supported by the heart rate and the perceived exertion ratings. The fact that the dancers expressed that the workload was hard or very hard (RPE 16),[17] but in an emotional sense expressed only tiredness, supports the observation of dancers' determination to continue to cope even when faced with intense physical demand.[4,6] The results suggest a tendency toward a more disassociative type of attentional style. Within their own awareness, dancer may not have been monitoring and responding to maintain efficiency. A disassociative type of attentional style has been shown in

TABLE 4. SEES at Before and After the Incremental Fatiguing Dance Protocol

Dimension/Item	Pre-Fatigue Protocol	Post-Fatigue Protocol	p Value*
Positive well-being	20.26 ± 4.29	20.93 ± 3.96	0.53
Strong	4.70 ± 1.46	4.78 ± 0.94	1.00
Great	5.08 ± 1.35	5.67 ± 1.15	0.32
Positive	5.63 ± 1.01	5.07 ± 1.98	0.72
Terrific	4.85 ± 1.63	5.41 ± 1.13	0.24
Psychological distress	6.45 ± 2.33	7.60 ± 4.32	1.00
Crummy	1.59 ± 0.78	1.96 ± 1.77	0.89
Awful	1.89 ± 1.10	1.81 ± 1.09	0.87
Miserable	1.22 ± 0.34	2.00 ± 1.51	0.11
Discouraged	1.74 ± 0.91	1.82 ± 0.65	0.40
Fatigue	10.79 ± 3.81	14.21 ± 10.00	0.09
Exhausted	2.74 ± 1.49	3.67 ± 1.67	0.20
Fatigued	2.33 ± 1.18	3.25 ± 1.12	0.14
Tired	2.63 ± 1.42	3.96 ± 0.75	**0.04***
Drained	3.07 ± 1.68	3.26 ± 1.68	0.44

*Data expressed as mean ± SD. $p < 0.05$ denotes significance.

endurance athletes,[16] although the possibility of its existence in contemporary dancers is yet to be fully explored.

It is acknowledged that this fatigue protocol, albeit limited by sample size, did attempt to develop a modality-specific, multidimensional approach to the assessment of the physical demand capabilities of contemporary dancers. The dancers showed a significant increase in cardiovascular response, although there was only a significant change in tiredness and no change in the postural stability indices. Further development of this protocol is suggested, with an elimination of the time period between the dancer reaching RPE 16 and the collection of post-exercise postural stability data. It is also suggested that the protocol be further validated and supported by a comparison with standard ergometer-based exercise testing.

This initial investigation examined aspects of fatigue and its effect on performance being part of the continued promotion of improved standards and awareness training. As contemporary dancers begin their careers at an early age, often with high levels of physical and mental demand, it is important for dancers and instructors to have accessible methods that accurately monitor training regimes, both to enhance performance and to reduce the risk of injury and illness.

REFERENCES

1. Throsby D: Dance in Australia—A Profile. Macquarie, Australia: Australian Dance Council, 2004. http://www.ausdance.org.au/outside/transition/DanceinAust.pdf.
2. Throsby D, Hollister V: Moving On: Career Transition of Professional Dancers in Australia. Macquarie, Australia: Australian Dance Council, 2005. http://www.ausdance.org.au/outside/transition/Movingon.pdf.
3. Koutedakis Y, Myszkewycz L, Soulas D, et al: The effects of rest and subsequent training on selected physiological parameters in professional female classical dancers. Int J Sports Med 1999;20:379–383.
4. Hamilton L, Kella J, Hamilton W: Personality and occupational stress in elite performers. Med Probl Perform Art 1995;10:86–89.
5. Khan K, Brown J, Way S, et al: Overuse injuries in classical ballet. Sports Med 1995;19:341–357.
6. Koutedakis Y, Jamurttas A: The dancer as a performing athlete. Sports Med 2004;34:651–661.
7. Heil J: Psychology of Sport Injury. Campaign, IL: Human Kinetics, 1993.
8. Hanrahan S: Dancers perceptions of psychological skills. Rev Psicol Deporte 1996;9–10:19–27.
9. Rushall B, Pyke F: Training for Sports and Fitness. Melbourne: Macmillan Education Australia Pty Ltd, 1990.
10. Koutedakis Y, Sharp N: Thigh-muscles strength training, dance exercise, dynamometry, and anthropometry in professional ballerinas. J Strength Cond Res 2004;18:714–718.
11. McArdle W, Katch F, Katch V: Exercise Physiology: Energy, Nutrition and Human Performance, 5th ed. Philadelphia: Lippincott Williams & Wilkins, 2001.
12. Wasserman K, Hansen J, Whipp B, Casaburi R: Principles of Exercise Testing and Interpretation, 2nd ed. Baltimore: Williams & Wilkins, 1994.
13. Noakes T: Physiological models to understand exercise fatigue and the adaptations that predict or enhance athletic performance. Scand J Med Sci Sports 2000;10:123–145.
14. Ageberg E, Roberts D, Holmstrom E, Friden T: Balance in single-limb stance in healthy subjects—reliability of testing procedure and the effect of short-duration sub-maximal cycling. BMC Musculoskelet Disord 2003;4(1):14.
15. Hardaker W, Margello S, Goldner J: Foot and ankle injuries in theatrical dancers. Foot Ankle 1985;6(2):59–69.
16. Morgan WP, Pollock ML: Psychological characterization of the elite distance runner. Ann NY Acad Sci, 1977;301:382–403.
17. Borg G: Psychological bases of perceived exertion. Med Sci Sports Exerc 1982;14(5):377–381.
18. McAuley E, Courneya K: The subjective exercise experiences scale (SEES): development and preliminary validation. J Sport Exerc Psych 1994;16:163–177.
19. Nix N, Gilleard W: Stability in intermediate level female gymnasts performing a handstand. Presented at: Australian Association for Exercise and Sports Science Inaugural National Conference, Brisbane, 13–16 April 2004.
20. Katayama Y, Senda M, Hamada M, et al: Relationship between postural balance and knee and toe muscle power in young women. Acta Med Okayama 2004;58(4):189–195.
21. Vuillerme N, Nougier V, Prieur J: Can vision compensate for lower limbs muscular fatigue for controlling posture in humans? Neurosci Lett 2001;308(2):103–106.
22. Golomer E, Cremieux J, Dupui P, et al: Visual contribution to self-induced body sway frequencies and visual perception of male professional dancers. Neurosci Lett 1999;267(3):189–192.
23. Schmit JM, Regis DI, Riley MA: Dynamic patterns of postural sway in ballet dancers and track athletes. Exp Brain Res 2005;163(3):370–378.