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The measurement of competitive anxiety during balance beam performance in gymnasts

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Abstract

The purpose of the present study was to investigate competitive anxiety during balance beam performance in gymnasts. Competitive anxiety was assessed continuously by heart rate monitoring and by retrospective self-report of nervousness in eight female national level gymnasts during their balance beam routine during one competition and two training sessions. A significant negative correlation was found between the score of the retrospective self-report of nervousness and performance during the routine. There were no significant differences in performance score by the judges between the three test sessions. There were also no differences in the retrospective self-report of nervousness. However, heart rate was significantly higher during the competition session than during the training sessions. The potential value of the retrospective report of nervousness for the study of critical events during gymnastic performance is illustrated. The results are discussed in the light of catastrophe theory.

Keywords: *Anxiety, balance, gymnastics, heart rate, retrospective assessment, catastrophe theory*

Introduction

The effect of competitive anxiety upon performance has received considerable attention. It is often assumed that anxiety during competition – that is, a negative emotional state characterized by feelings of nervousness, worry, apprehension and bodily arousal – has beneficial or detrimental effects upon sport performance (Weinberg & Gould, 1995).

Anxiety may be important in gymnastics, particularly during balance beam performance, where elements of high difficulty are performed on a 10 cm wide beam at a height of 125 cm. Factors such as risk of injury (Kolt & Kirkby, 1994; Magyar and Chase, 1996; Sands, 2000; Tofler, Stryer, Micheli, & Herman, 1996) and the subjective scoring system of the judges (Krane & Williams, 1985; Weiss, Wiese, & Klint, 1989) contribute to anxiety. Gymnasts perceive less anxiety in their own training facility than in a competition facility (Gould, Petlichkoff, & Weinberg, 1984; Kerr & Pos, 1994; Matheson & Mathes, 1991; Williams, Frank, & Lester, 2000). indicating an increase in anxiety when situational factors become more unfamiliar. Several studies have suggested that anxiety may decrease balance performance of gymnasts. Weinberg and Gould (1995) claimed that anxiety leads to an increase in muscle tension and a decrease in coordination. In a more clinical setting, Maki and Whitelaw (1993) and Maki and McIlroy (1996) showed that anxiety has a negative influence on balance parameters, as measured by posturography.

Sudden events (loss of balance, fall, etc.) during the balance beam routine can significantly influence one's perception of anxiety. As described in Hardy's catastrophe theory (Fazey & Hardy, 1988; Hardy, 1990; Hardy & Parfitt, 1991), these events can significantly influence the level of cognitive anxiety and interfere with the performance outcome. This theory states that performance is influenced by physiological arousal and cognitive anxiety. In a state of low cognitive anxiety, the relationship between physiological arousal and performance will be an inverted U. In a state of high cognitive anxiety, on the other hand, the relationship will be a catastrophe. This means that after reaching the optimal level of physiological arousal, performance will decrease dramatically (catastrophe). As a consequence, it is cognitive anxiety that prescribes

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the influence of physiological arousal on athletic performance. Fazey and Hardy (1988) stated that physiological arousal should only be negatively related to performance when the level of cognitive anxiety is high. In this theory, it is clear that the relationship between anxiety and performance is dynamic and may change within a few seconds. To capture these temporal dynamics of competitive anxiety, continuous measurement of anxiety during performance is necessary.

Most research (Jones & Cale, 1989; Krane & Williams, 1985; Matheson & Mathes, 1991) on competitive anxiety has relied on the use of self-report inventories that assess competitive anxiety before and after the competition. The Competitive State Anxiety Inventory-2 (CSAI-2; Martens, Vealy, & Burton, 1990), which assesses cognitive anxiety, somatic anxiety and self-confidence, is frequently used. One disadvantage of questionnaires is that it is difficult to measure the temporal dynamics of anxiety during performance (Jones, Swain, & Hardy, 1993; Martens *et al.*, 1990).

The measurement of physiological parameters such as heart rate, skin conductance and muscle activity (Collins, 1992) allows a continuous analysis of the relationship between physiological arousal and performance. Physiological arousal is also a component of catastrophe theory. However, the measurement of physiological parameters alone is insufficient to reveal the true nature of the relationship between anxiety and athletic performance. There is a consensus that anxiety is a multidimensional construct (Martens *et al.*, 1990) and that physiological and psychological parameters must be studied simultaneously (Gould & Krane, 1992; Robazza & Bortoli, 2003). Robazza, Bortoli and Nougier (1999, 2000) combined the measurement of physiological and psychological parameters. In a case study, heart rate was measured during an archery competition and emotions were established by interviewing the athlete before and during pauses in the event.

The primary purpose of the present study is to continuously measure anxiety during balance beam performance. In the light of catastrophe theory, we predict that physiological arousal should be deleterious to balance beam performance only if cognitive anxiety is high. If cognitive anxiety remains low, increases in physiological arousal will not deteriorate performance. We also undertake a preliminary investigation of critical moments of the routine.

Methods

Participants

Eight female Belgian gymnasts from two different gymnastics teams volunteered for this study. These national level gymnasts had 3–10 years of gymnastics experience (mean = 7 years, $s = 2.07$) and they trained 18–24 h per week (mean = 20.3 h, $s = 2.4$). The start values of the routines ranged from 7.2 to 8.8 (mean = 8.10, $s = 0.54$). The gymnasts ranged in age from 11 to 15 years (mean = 13.4 years, $s = 1.3$). Informed consent was obtained from the participants and their parents. The study was approved by the ethics committee of University Hospital Ghent.

Timing of tests

The participants performed a balance beam routine on three occasions. The first routine was performed during a training session in the participants' own training facility during the preparation period in December. The second routine was performed during a training session in the same training facility, but during the competition period in February. The final routine was performed during a competition between the two participating teams, during the competition period in February, in an unfamiliar facility with judges and an audience. These judges were different from the judges who assessed the performance scores that were analysed in this study. It was expected that the level of anxiety would be higher during the first than during the second training session, because the elements of the balance beam routine were yet to be fully mastered by the gymnasts. An increase in anxiety between the training sessions and the competition was expected due to the increased importance of the event.

Physiological measurement

Heart rate frequencies were measured beat per beat before, during and after the balance beam routine with a telemetric heart rate monitor (Polar Vantage NV™). To ensure that the gymnasts were not inconvenienced, the watch was taped to their back. Before the test, the gymnasts assessed if the normal competition routine could be performed with the watch in place. None of the gymnasts reported being hindered by the heart rate monitor. After each session, the heart frequencies were transmitted to a personal computer. Measurement errors were filtered with the Polar Precision Performance™ Software for Windows®. The filter was set at a moderate filter power and a minimum protection zone of 6 beats · min^{-1}. These errors occurred in particular during the acrobatic elements of the balance beam routine. During other elements (gymnastic, holds and stands, dance) of the routine, the software program did not detect any errors. The beat-to-beat heart rate values were converted into a continuous time axis in seconds and five variables were calculated from these data, namely the heart rate at rest (HR_{rest}), the average heart rate during the 5 s before the beginning of the routine (HR_{before}), the average heart rate during the routine (HR_{during}), the heart rate after the dismount at the end of the routine (HR_{end}) and the average heart rate during the last 5 s of a one-minute recovery ($HR_{recovery}$). Heart rate at rest was measured in a seated position during a one-minute interval, 5 min before the balance beam routine.

Self-report scale

The retrospective self-report of nervousness (RS) was obtained immediately after the end of the one-minute recovery period. The participants were asked to score their anxiety on a Likert like scale from 1 ("not nervous at all") to 7 ("very nervous") in response to the question "How nervous were you at that moment of your balance beam routine?" The same question was posed with the "anxiety thermometer" (Bakker, Vanden Auweele, & Van Mele, 2003). The anxiety thermometer is a 10 cm continuous scale on which participants have to rate their nervousness, ranging from 0 ("not nervous at all") to 10 ("extremely nervous"); it has been used previously (Pijpers, Oudejans, Holsheimer, & Bakker, 2003). The anxiety thermometer scores correlate similarly with cognitive anxiety scores and somatic anxiety scores on the CSAI-2 [$r = 0.59$ and $r = 0.62$ respectively (Bakker *et al.*, 2003)]. The balance beam routine was videotaped with a digital camera (50 Hz) and, during recovery, the recording was rewound to the beginning of the balance beam routine. While watching the replay of their beam performance, the participants indicated their perceived anxiety on the 7-point scale on a personal computer. The participants typed the value (from 1 to 7) on a modified keyboard and these data were stored in a spreadsheet at a rate of 10 Hz. The same instants in time as for the heart rate data were used as the retrospective scale variables: RS_{rest} (at rest), RS_{before} (before the routine), RS_{during} (during the routine) and RS_{end} (at the end of the routine). No self-report of nervousness was measured at the end of recovery, because a pilot study had revealed that the gymnasts consistently reported the same score after recovery as at the end of the routine. The retrospective self-report scale data were synchronized on the same time axis as the heart rate data for further evaluation.

A Dutch version of the CSAI-2 (Bakker *et al.*, 2003) was administered 1 h before each routine. The inventory consists of three subscales: cognitive anxiety, somatic anxiety and self-confidence. Each subscale contains nine statements with a score from 1 ("not at all") to 4 ("very much so"). This gives subscale scores ranging from 9 to 36. The CSAI-2 has been shown to have good internal consistency and construct validity. The Anti-Social Desirability Instructions, as proposed by Martens *et al.* (1990), were respected.

Performance

In line with other studies (Jones *et al.*, 1993; Winfrey & Weeks, 1993), the beam performance was a competition balance beam routine, individually put together within the restrictions of the "Code de Pointage" of the Fédération Internationale de Gymnastique (2000). The routines of the participants were not identical, but the start values of the routines were very similar (mean = 8.10, $s = 0.54$), indicating the same level of difficulty for each routine. All routines were scored by five international judges, who had no connections with the gymnasts and who were not informed about the purpose of the study. These routines were randomly presented on videotape. Because all three test occasions were videotaped against a neutral background, it was impossible for the judges to know which of the three tests the gymnasts were performing. The lowest and the highest score were eliminated and the other three were averaged, giving the performance score. This score can vary from 0 to 10 points. The jury is trained to score objectively and the Fédération Internationale de Gymnastique has established vigorous norms and rules to enhance this objectivity. This procedure was in accordance with the study of McAuley (1985).

The numbers of falls per gymnast and per routine were recorded, because a fall results in a 0.5 point penalty. This is critical, because differences among elite gymnasts are very small and the difference between a medal and an anonymous ranking is often decided by tenths of a point.

Data analysis

This was designed as an intra-individual study and repeated measures were used for statistical analysis. The Friedman test and the Wilcoxon test (*post hoc*) were used to examine differential effects of test occasion and the Spearman rank correlation was used for correlation analysis between the heart rate data, the performance score variables, the retrospective self-report scale variables and the subscales of the CSAI-2. Non-parametric tests were used because several data sets departed from normality. Statistical significance was set at $P < 0.05$.

Results

Heart rate frequencies

Heart rate frequencies (Figure 1) increased significantly from rest to the end of the routine (training

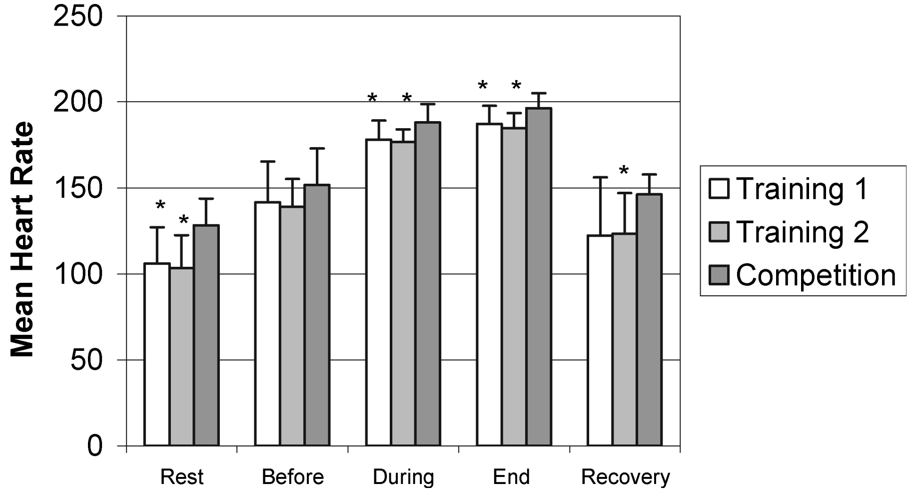

Figure 1. Mean heart rate (beats · min^{-1}) at rest, before, during and at the end of the routine, and after recovery on the three test occasions ($n = 8$). *Significantly different ($P < 0.05$) from the competition session.

session 1: $\chi^2_4 = 30.5$, $P < 0.01$; training session 2: $\chi^2_4 = 29.8$, $P < 0.01$; competition session: $\chi^2_4 = 29.3$, $P < 0.01$). After the one-minute recovery, heart rate decreased significantly.

All heart rate variables at the corresponding instants in time (Figure 1) were significantly lower during the training sessions than during the competition session (HR_{rest}: $\chi^2_2 = 9.25$, $P < 0.05$; HR_{during}: $\chi^2_2 = 7$, $P < 0.05$; HR_{end}: $\chi^2_2 = 9.25$, $P < 0.05$; $HR_{recovery}$: $\chi^2_2 = 9.25$, $P < 0.05$), except HR_{before} ($\chi^2_2 = 0.75$, N.S.). There were no significant differences in heart rate data variables at the corresponding instants in time for the first and second training sessions.

Self-report scales

There were no significant differences in the retrospective self-report scale scores at the different instants in time, except for a significant decrease in score at the end of the routine compared with the other three time points during the second training session and the competition session (training session 2: $\chi^2_3 = 11.22$, $P < 0.05$; competition session: $\chi^2_3 = 14.91$, $P < 0.01$).

There were no significant differences in the respective retrospective scale variables on the three test occasions (RS_{rest}: $\chi^2_2 = 3.36$, N.S.; RS_{before}: $\chi^2_2 = 1.92$, N.S.; RS_{during}: $\chi^2_2 = 1$, N.S.; RS_{end}: $\chi^2_2 = 1.62$, N.S.), indicating that the participants did not perceive a different level of anxiety during the three test occasions.

The mean (± standard deviation) values for cognitive anxiety, somatic anxiety and self-confidence on the three test occasions were, respectively: 23.25 ± 3.33, 24 ± 3.7 and 21 ± 4.31 for training session 1; 20 ± 3.25, 21.75 ± 5.85 and 20.63 ± 5.21 for training session 2; and 21.13 ± 4.67, 21.50 ± 4.38 and 20.88 ± 3.6 for the competition session. None of the three subscales of the CSAI-2 showed significant differences on the three test occasions (cognitive anxiety: $\chi^2_2 = 2$, N.S.; somatic anxiety: $\chi^2_2 = 1.5$, N.S.; self-confidence: $\chi^2_2 = 0.87$, N.S.).

Performance scores

The mean (± standard deviation) performance scores on the three test occasions were, respectively: 5.50 ± 0.89 for training session 1; 5.85 ± 1.10 for training session 2; and 5.86 ± 0.74 for the competition session. The performance score did not differ significantly ($\chi^2_2 = 1.45$, N.S.) between the three test occasions.

The mean number of falls, registered per gymnast and per routine, during the balance beam routine on the three test occasions were, respectively: 0.87 ± 0.64 for training session 1; 1.13 ± 1.55 for training session 2; and 1.25 ± 1.28 for the competition session. The mean number of falls did not differ significantly ($\chi^2_2 = 0.35$, N.S.) between the three test occasions.

Correlations

A complete overview of the correlation analysis is given in Table I. Correlations were calculated among the 24 balance beam routines (8 participants × 3 test occasions). There were no significant correlations between performance score and the subscales of the CSAI-2. The only significant correlation between performance score and the retrospective self-report was a negative correlation ($r_s = -0.44$, $P < 0.05$) during the routine.

Table I. Mean, standard deviation (s) and inter-correlations (Pearson rank correlation) between the CSAI-2 scales, heart rate and the retrospective self-report scale variables.

	$N = 24$	Mean	s	2	3	4	5	6	7	8	9	10	11	12	13
1	CA	21.46	1.65	0.55**	−0.28	−0.10	−0.25	−0.76	−0.16	0.15	0.48*	0.45*	0.60*	0.09	−0.27
2	SA	22.42	1.38		−0.39	0.23	0.12	0.25	0.10	0.45*	0.17	0.16	0.17	0.27	0.20
3	SC	20.84	0.19			−0.09	0.22	0.01	0.01	−0.12	−0.04	−0.07	−0.02	−0.41*	−0.08
4	HR_{rest}	112.64	13.68				0.71**	0.67**	0.62**	0.78**	−0.10	−0.13	−0.06	0.33	−0.08
5	HR_{before}	144.19	6.60					0.70**	0.52**	0.64**	−0.27	−0.30	−0.21	0.16	0.13
6	HR_{during}	180.97	6.22						0.88**	0.76**	−0.06	−0.11	−0.22	0.24	0.15
7	HR_{end}	189.47	6.06							0.66**	−0.03	−0.07	−0.27	0.27	−0.01
8	$HR_{recovery}$	130.69	13.55								0.11	0.05	−0.05	0.16	0.11
9	RS_{rest}	5.09	0.36									0.99**	0.72**	−0.05	−0.06
10	RS_{before}	5.05	0.29										0.75**	−0.03	−0.07
11	RS_{during}	4.88	0.02											0.22	−0.44*
12	RS_{end}	3.38	0.25												−0.21
13	PS	5.74	0.21												

*$P < 0.05$; **$P < 0.01$.

Abbreviations: cognitive anxiety (CA); somatic anxiety (SA); self-confidence (SC); heart rate at rest (HR_{rest}), before the routine (HR_{before}), during the routine (HR_{during}), at the end of the routine (HR_{end}) and after 1 min of recovery ($HR_{recovery}$); scores on the retrospective self-report scale at rest (RS_{rest}), before the routine (RS_{before}), during the routine (RS_{during}) and at the end of the routine (RS_{end}); performance score (PS).

There were significant correlations between cognitive anxiety and the retrospective self-report at rest ($r_s = 0.48$, $P < 0.05$), before the routine ($r_s = 0.45$, $P < 0.05$) and during the routine ($r_s = 0.60$, $P < 0.01$). A significant negative correlation ($r_s = -0.41$, $P < 0.05$) was observed between self-confidence and the retrospective self-report at the end of the routine.

Case study

A further qualitative analysis of the separate elements of the routine makes it possible to focus on such critical events as disturbance of balance and falls for those elements during the routine. A case study illustrates the potential value of this qualitative analysis. By comparing heart rate and the retrospective self-report before, during and after the performance of a difficult acrobatic element (flic-flac), some intriguing data were obtained. The gymnast fell, while performing this element, during training session 2, but remained on the balance beam during training session 1. A substantially higher heart rate (137 beats $\cdot$ min^{-1} in the session in which the gymnast fell and 127 beats $\cdot$ min^{-1} in the session in which the gymnast remained on the beam) was observed before the flic-flac in training session 2 (Figure 2).

During and after the performance of the flic-flac, there were no differences in heart rate between the two sessions. This finding is consistent with the retrospective self-report scale scores, where before the flic-flac a score of 4 was reported in the session without a fall and a score of 6 in the session with a fall. The retrospective self-report remained constant during the performance of the flic-flac, but at the end of the element, the retrospective self-report dropped to a value of 2 for the session without a fall but remained at 6 for the session with a fall.

Discussion

The purpose of this study was to continuously measure anxiety during balance beam performance in gymnasts by means of retrospective evaluation and heart rate assessment. There were no differences in balance beam performance, or self-reported feelings of nervousness, between the competition and training sessions, despite a significant increase in heart rate during the competition session. The case study shows that the continuous monitoring of anxiety allows the investigation of unexpected events during performance.

It was hypothesized that anxiety would have a negative impact on the balance beam performance of gymnasts. During the routine, a negative correlation was observed between the retrospective self-report

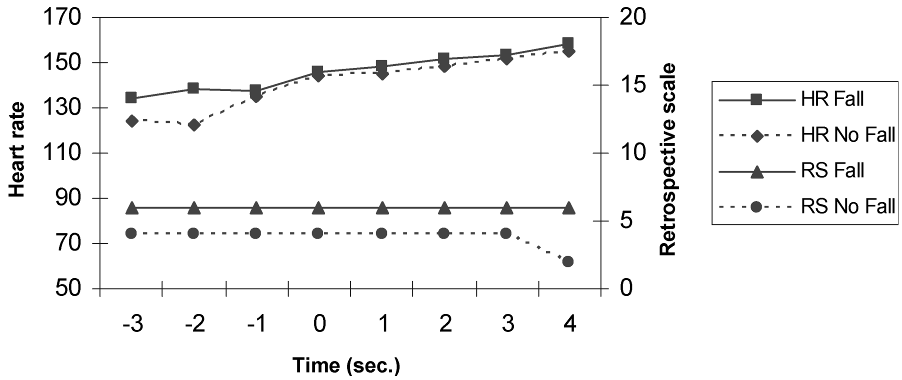

Figure 2. Heart rate (HR; beats · min^{-1}) and retrospective self-report scale scores (RS) before (from -3 to -1 s), during (from 0 to 3 s) and after (4 s) the performance of a flic-flac by the same gymnast on two occasions: with a fall and without a fall.

scale score and performance. This finding suggests that a high retrospective self-report score of nervousness during the routine is debilitative for balance beam performance. This finding was not confirmed by other measurements of anxiety, such as heart rate or the subscales of the CSAI-2.

Heart rate was significantly higher in the competition session than in the two training sessions, suggesting greater physiological arousal in the competition session. Robazza *et al.* (1999) also observed an increase in heart rate in an archer during competition compared with training. Although the performance scores of the archer did not differ between training and competition sessions, the archer perceived the higher heart rate as facilitating optimal performance. In present study, similar results were obtained. A higher heart rate in the competition session was not debilitative for the balance beam performance. In the present study, neither the retrospective self-report scale scales, nor the different subscales of the CSAI-2, differed between the training and competition sessions. These findings are at odds with those of other studies of gymnasts. Krane and Williams (1985) and Matheson and Mathes (1991) observed an increase in cognitive anxiety and somatic anxiety, and a decrease in self-confidence, as the competition approached. However, it is possible that the gymnasts in these studies perceived the training sessions differently, because there were no performance measurements during these sessions. In the present study, the gymnasts had to perform their competition balance beam routine during the training sessions and no differences in self-reported anxiety were found compared with the competition session. These results suggest that performing the balance beam routine caused the gymnasts anxiety, which was not altered by the importance of the event.

In the CSAI-2, the question "I feel nervous" represents a somatic component of anxiety. However, in the present study there was a correlation between the retrospective self-report scale scores and the cognitive component of anxiety, but no correlation between the retrospective self-report scale scores and the somatic component of anxiety. This indicates that the retrospective self-report scale score has a cognitive component.

It was hypothesized that anxiety would be higher during the training session in the preparation period than in the training session in the competition period. The rationale for this hypothesis was that the elements of the balance beam routine are not completely mastered after the first training session. This uncertainty of the outcome could have led to greater anxiety. However, in the present study, we found no significant changes in heart rate or self-report scale scores. These findings are in accordance with those of Robazza *et al.* (1999), who found no changes in heart rate between training sessions of an elite archer. However, these training sessions took place over a matter of days, whereas in the present study they were separated by 3 months. Because the performance scores did not differ between the two training sessions either, it is possible that the beam routines were already mastered by the gymnasts after the first training session. This is also illustrated by the absence of significant changes in the number of falls.

The discrepancy between perceived physiological arousal (e.g. somatic anxiety subscale of the CSAI-2) and actual physiological arousal (e.g. heart rate) has been described elsewhere (Gould *et al.*, 1984; Helin, 1988; Martens *et al.*, 1990) and provides evidence for the multidimensional nature of anxiety. Our results support the notion that the combination of physiological and psychological measurements is desirable to reveal the true nature of competitive anxiety, as stated by Caruso, Gill, Dzewaltowski and McElroy (1990).

Our results are in line with Hardy's catastrophe theory (Fazey & Hardy, 1988; Hardy, 1990; Hardy & Parfitt, 1991). In the present study, an increase of physiological arousal (heart rate) was found in the competition session, but because cognitive anxiety (retrospective self-report scale) remained low, no performance decrement was observed. But because the shared variance (r^2) between the retrospective self-report scale scores and cognitive anxiety (CSAI-2) was rather low, these assumptions of catastrophe theory must be treated with caution. Robazza *et al.* (1999) claimed that high arousal leads to performance impairment, when somatic symptoms of activation are individually perceived as debilitating anxiety. It is possible that the gymnasts in the present study did not feel their increased physiological arousal as debilitative, or that they were not aware of it. Jones, Swain and Cale (1990) extended the original CSAI-2 by using a direction scale to elucidate the facilitative and debilitative characteristics of the intensity of anxiety. The retrospective self-report scale in the present study consisted only of an intensity scale. The use of a direction dimension would be useful in future studies.

The results of the case study illustrate the potential of the continuous measurement of anxiety. By measuring anxiety during sport performance, sudden events such as falls can be studied. A lower heart rate was found before performance of the same element during a training session when the gymnast remained on the beam, compared with a training session when the gymnast fell off the beam. When the gymnast did not fall, she reported lower retrospective self-report scale scores before the performance of the element; this indicates that the gymnast experienced less cognitive anxiety in this situation. This finding suggests that a lower heart rate and lower cognitive anxiety before performing a difficult element are facilitative to good performance. Further research is needed to elucidate the role of a lowered heart rate and lowered self-reported anxiety.

Although much useful information is obtained using retrospective self-report scale scores and retrospective interviews have been used to learn more about athletes' feelings during competition (Butt, Weinberg, & Horn, 2003; Hanton & Connaughton, 2002; Robazza *et al.*, 1999), some remarks are necessary. Retrospective contamination (Kolt & Kirkby, 1994; Landers *et al.*, 1994) is a potential threat. Festinger (1957) stated in his theory of cognitive dissonance that individualss are willing to harmonize their thoughts with their actions. A gymnast is tempted to attribute a good performance to low anxiety and poor performance to high anxiety. However, Tenenbaum, Lloyd, Pretty and Hanin (2002) and Tenenbaum and Elran (2003) found congruence between actual and retrospective reports of emotions for pre- and post-competition states. In the present study, the retrospective report was assessed immediately after performing the balance beam routine, so biases in memory were limited.

The use of heart rate frequency as a measure of anxiety is useful in the resting state (e.g. test anxiety), but is less evident during exercise. The gradual increase in heart rate frequency during the balance beam routine is mainly caused by the increased energetic demand. But because the same balance beam routines were performed on the different test occasions and an intra-individual approach was chosen, the higher heart rate during the competition session can be explained in terms of increased arousal, which can be related to increased anxiety. Moreover, during the competition session, a significantly higher heart rate was also found at rest. The effects of falls must be highlighted, which result in substantial differences in cardiovascular outcome by having to remount on the balance beam. Further qualitative research is needed to elucidate this problem.

Because only eight gymnasts participated in the present study, general conclusions must be drawn with caution. However, case studies and studies in small populations (Prapavessis, Grove, McNair, & Cable, 1992; Robazza *et al.*, 1999, 2000) have provided important insights into the anxiety – performance relationship. In elite athletes, an individual orientated approach is often more effective than group strategies.

In summary, the results of the present study indicate that the continuous measurement of cognitive anxiety and physiological arousal during balance beam performance can provide insight into the anxiety – performance relationship. An increase in physiological arousal in the competitive setting compared with training sessions does not lead to performance decrements, because cognitive anxiety remains stable. The findings of this study can be explained in the light of catastrophe theory.

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