

PSYCHOLOGICAL PROCESSES INVOLVED DURING ACROBATIC PERFORMANCE: A REVIEW

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Review paper

Abstract

Acrobatic performance has provided a particularly rich context for sport science research. Currently a high number of publications on acrobatic performance are represented in domains such as biomechanics, physiology and traumatology. However, at present, no research synthesis has yet been reached in the psychological domain. The aim of this article is to review literature on models and empirical research linked to the psychological processes involved in acrobatic performance. This review demonstrates the improvement of scientific knowledge in sport psychology on acrobatic practice. Following literature searches 66 articles were found to combine acrobatic performance and sport psychology. These articles were inductively analysed to reveal three main research themes: (a) the organization of performance, (b) the preparation of performance and (c) the subjects' transformation by the practice of acrobatics. These articles are reviewed and further suggestions for future research advances are made.

Key words: *action, cognition, context, elite performance, acrobatic, sport psychology*

Introduction

Acrobatic performance has represented a particularly productive context for sport science research. The domain of acrobatic performance includes a number of characteristics which may be responsible for this high frequency of scientific interest. These characteristics include: (a) the complex perceptive and particular activity that is closely linked to the body's rotation in the air. (b) The subjective judgement of the performed skill combined with the level of perfection of the movement. This fundamentally questions the motor skills, their room for improvement, their capacity for repetition and their aesthetic components. (c) The risk assessment of the athlete that is demonstrated by bigger movement amplitudes and higher and more complex rotations which use singular cognitive and affective resources (d) The existence of numerous physical and sporting examples in which acrobatic performances are evident, such as the goal celebration in soccer. (e) The technological innovations which are enriching scientific interest of this activity by associating the body of the athlete with the machine, for example in FMX or in the acrobatic plane. Research using acrobatic performance has been extensive. This wealth of research has led to acrobatic review publications in biomechanics (Bruggemann et al., 1994; Yeadon & Challis, 1994; Prassas et al., 2006), on acrobatic injury (Graption & Barrault, 1999) and in gymnastic physiology (Jemni et al., 2001). However, no synthesis has yet been produced examining the psychological domain. This article presents a review of literature concerning models and empirical research linked to the psychological processes of acrobatic performance. It aims to demonstrate the evolution of scientific knowledge in the applied sport psychology of acrobatic practices and to evaluate the further opportunities for research.

Methods

Data collection involved a two step process. First, a literature search limited to the term acrobat* and including only peer reviewed articles was completed using SPORTDiscus®. This resulted in one hundred and sixteen articles. For each study that was reported the associated acrobatic sport was recorded (e.g., trampolining, diving). A second search was then performed using the platform Web of Science®. For this search, using only the terms acrobatics or tumbling or diving or gymnast* or trampoline*, 15,713 documents were identified.

These documents were sorted systematically using the following criterion: documents types only (12,926 articles) then Subject areas: (i.e., sport science - 3175 articles) then Publication years (from 1978 to 2008 -2475 articles) and finally, Sources title: (i.e., psychology, behaviour, motor, medicine and sport; thereby excluding the terms biomechanics, podiatry, orthopaedics therapy, history, sociology - 599 articles). Finally, the articles were sorted by title, excluding for example the terms history and sociology. A total of 66 articles were found to correspond to the final selection criteria. For each of the 66 articles found, inductive content analysis was used (e.g., Patton 1990; Thomas 2006) to let categories and sub-categories emerge. Each category theme can be divided in subcategories characterizing a particular component of analysis as demonstrated (Figure 1).

Results

Three categories of research emerged from this analysis: (a) the organization of acrobatic performance, (b) the preparation of performance and (c) the subjects' transformation by the practice of acrobatic sports. Results are presented using these categories.

The organization of acrobatic performance

Four subthemes of study characterized the analysis of acrobatic performance: expertise, perception, memory and knowledge.

Expertise

There were nine research articles that were included in this theme. One research axis in this theme suggests possible existing links between cognitive and behavioural aspects of performance. Spink (1990) examined the differences in cognitive and behavioural processes between male gymnasts from different competitive levels. Thirty-eight gymnasts completed a questionnaire that focused on psychological factors impacting on both training and competition. Spink revealed that two psychological factors varied according to level of expertise. The first was psychological recovery, the second was self-confidence. In particular, higher level gymnasts were found to recover better psychologically from mistakes made during competition. Following this analysis of expertise, Slobounov, Yukelson and Obrien (1997) examined the potential links between the variability of routines, self-efficiency, self-evaluation and the level of expertise of springboard dives of Olympic level athletes. Their analysis showed that the variability of the kinematics parameters was linked to the level of difficulty of the springboard dive. Further, feelings of self-efficiency and self-evaluation also improved with increased expertise. Moreover, Hinton-Bayre and Hanrahan (1999), in an exploratory and comparative study, identified the differences in personality variables between a sample of 18 elite divers (i.e., springboard and platform) and non divers. Results demonstrated that elite level divers had a higher level of confidence in their physical performance and in their appearance than non divers however, the impact of personality on performance could not be predicted. Emotions have also been considered as an important factor influencing performance excellence. Robazza, Pellizzari and Hanin (2004) examined the multimodal and individual consequences of self-regulation strategies on emotions in relation to bodily symptoms. Four athletes (4 hockey goal keepers and 4 gymnasts) took part in an Individual Zones of Optimal Functioning (IZOF) test. Robazza et al. supported the hypothesis that using a mental training strategy would optimise psycho biosocial states before competition and would improve the performance of athletes during competition. Results suggest that this test could be used to examine the relationship between emotions and bodily symptoms. The second research axis in the domain of expertise has been inspired by knowledge based on the analysis of outstanding acrobatic performances in trampoline, tumbling and acrobatic skiing (Hauw, Berthelot & Durand, 2003). The methodological basis for this approach has been to analyse video recordings in parallel with self-confrontation interviews with high level athletes. Research has considered expertise as changes in coupling between context-action have been found to be

present, based on the analysis of performance of four trampolinists (13 routines comprising 10 skills during the World Championships of 1999). Results demonstrated that even if the expertise of trampolinists were homogeneous, these were not stable as there was a difference in the organisation of the coupling context-action. The analysis of expertise was situated, considering determined variables such as the chaining of actions, their rhythmic properties, the monitoring of the typical alternation between actions aimed transforming the routine and those aimed at analysing it during the routine. Hauw & Durand (2004) used 27 trampoline exercises performed by 10 athletes categorized in three levels (good, average, poor). Three patterns of activity corresponding to those levels of performance were identified. The level of performance could be distinguished by the increase of significant actions occurring at the same time and also by a reduction of actions put on hold and the emergence of new actions targeting an interaction with the situation. This study confirmed that expertise could be distinguished through the identification of meaningful actions modified by the interactions with the context. Further research from Hauw & Durand (2008) aimed to understand the construction and the use of a meaningful time during the same high level acrobatic performance in different conditions (i.e., temporal). The results of this study suggest that the activity occurring during the acrobatic performance depends on the potential time available and that the activity or the cognition of the athlete can use this time to make the performance happen. The same acrobatic skill performed in different contexts (i.e., Tumbling, trampoline, acrobatic ski) involves differentiated mobilisations of the psychological process. Finally, Hauw, Renault & Durand (2008) examined the activity of elite acrobatic skiers, a sport characterised by a long time period in aerial flight. The aim of this study was to understand the processes that were engaged in order to achieve a good landing. An identical methodology was applied to three acrobatic skiers. The results showed an organisation of the action that could be split into six stages whereby the acrobat builds and modifies their activity based on their understanding and achievement of the jump. Finally, Delignières et al. (1998) analysed the preferable coordination mode used by beginners compared to experts during an oscillation on parallel bars. This demonstrated that in a new action beginners are strongly constrained by the intrinsic dynamism of the system and that mastering this spontaneous trend is difficult.

Perception

This theme was comprised of eight research articles. Rezzette and Amblard (1985) tested the hypothesis that the monitoring of acrobatic jumps would be dependent on a complex process of information collection. Trampolinists performed acrobatic jumps in three different visual conditions (in half-light, with a stroboscopic, and with normal light). Their results demonstrated that visual indications are important for performance in all of these conditions.

In particular, visual indications will be fundamental to stabilise the acrobatic landing. However, visual indications should be used less during the orientation of complex skills than during simple skills. The authors suggest the use of equivalent vestibular signs. Lee, Young and Rewt (1992) used the tucked forward salto to test the general assumptions of the control of speed approach (Gibson, 1958) and to apply this to the analysis of landing mechanisms in acrobatics. Two elite divers were studied while performing four series of ten saltos. The results demonstrated that landing control is less precise with eyes closed than with eyes open. These results confirmed the works of Rezzette and Amblard but also associated the hypothesis that landing was controlled by regulating body extension. According to Bardy and Warren (1997) vision will play two roles (a) to fix the speed of change of the tau angle to be compliant with the remaining time before reception and (b) to maintain constant change of the tau angle. Bardy and Laurent (1998) tested these strategies of body orientation control during the aerial and landing phase of backward somersaults. Their results suggested that information about aerial flight time was not taken into account by participants. On the contrary, the acrobats seemed to control their moment of inertia during the final phase of the somersault by managing the extension of their body together with the speed of time decrease before contact. These works have also been discussed using the dynamic theory of action-perception patterns. Schöner (1994) illustrated that the coupling of sight and body extension through postural adjustments would act as an attractor. Those attractors could be used to explain visual disturbances. This theory is illustrated by the example of the diving gannet and the landing fly in high diving in order to establish the variation of the tau angle in dynamic terms which is self-regulated. Moreover, two studies from Davlins, Sand and Shultz (2001a & b) have specified the role of peripheral vision of the segmented orientation control during the landing phase of the backward somersault. Ten female gymnasts with a good level of ability took part to this study. Backward somersaults were performed under four different conditions of vision: full vision field, horizontal peripheral vision limited to 100°, horizontal peripheral, horizontal peripheral vision limited to 60° and no vision. They concluded that gymnasts have a more stable landing when vision is full compared to the three other conditions and further, that they have a more stable landing by using peripheral vision compared to no vision. Finally, Luis and Tremblay (2008) examined the optimal use of visual feedback on segmented adjustment in backward somersaults depending on head position. Twelve experienced female gymnasts performed 20 backward somersaults under four experimental conditions: full vision, vision at AHV below 350 deg/s, vision at AHV above 350°/s and no vision. The authors concluded that during back somersaults, visual feedback is used to stabilize the landing with several head angles but that the optimal visual feedback is given when the retina is stable.

Memory and knowledge

Four articles were included this research theme. Initial research directions were developed from Ille and Cadopi (1999) who compared the reminding performance evolution of a gymnastics routine memory and the accountable processes of novices athletes aged between 8 and 14 years. Their results suggested that the performances memory improve with age and are better by experts than by beginners. The study outlined the role of amnesic strategies, as well as the knowledge base and the capacity of mental visualisation. Huber (1997) used springboard divers to demonstrate differences between elite divers and beginners linked to the representation of the problem and to the existing procedural knowledge. Four beginners and four experts were asked to describe their impressions after each springboard dive. The analysis of their descriptions outlined differences between beginners and experts in resolving problems. Experts had more conceptual understanding, thereby allowing them to link their problem with the process to solve it. Ozel, Larue and Molinaro (2002) tested the relationship between sport activity and the performance of a mental task of rotation with three experimental groups: gymnasts who used mental and physical rotations in their practice, athletes whose activities required very little motor rotation, and non athletes. The results suggest that the first two groups have quicker response times than the group of non athletes. The link between acrobatic activity and mental representation was identified by Schack (2003) who analysed the relationship between motor representations and the parameters of a complex acrobatic movement (the twist in gymnastics). Participants in this study were 30 beginners and experts. The aim was to use video observations to compare the mechanical parameters of the movement and the strategies of anticipation aiming to plan the consequences of the segmented placement at each part of the movement by using simple concepts and organising the motor expertise. The results supported the hypothesis that voluntary movements are planned, executed and decided on long term because the participants were able to anticipate. Thus it may be concluded that a link exists between the level of practice of the gymnast and their reminding performance.

Modes of preparation for acrob. performances

Motivation, Goals setting, competency

Ten articles were included in this research area. Feltz and Mugno (1983) extended the work of Bandura (1977) on the theory of competency. Their study tested the assumption that performance accomplishments, direct perception, physiological excitation and competence were the immediate causes which influenced perceived performance in back diving. The model suggests a strong relationship between the central nervous system and the feeling of competence. Additionally, Winfrey and Weeks (1993) examined the effects of self-modeling on self-efficacy and balance beam performance.

Intermediate level gymnasts were separated into two groups: self-modeling videotapes or control group. Results suggest that self-modeling can improve both the skill and the comprehension of feedback. More recently, Feltz et al. (2008) refined the relationship between competency and the central nervous system to answer earlier criticism from Bandura (1997). This concluded that the feeling of competence following the most recent performance was a better indicator of overall performance. Goal setting has also been shown as an important aspect of performance preparation. Pierce and Burton (1998) examined the impact of goal-setting styles on a goal-setting program for 25 female junior gymnasts. Results suggested that competition-oriented gymnasts improved their performance significantly over the course of time when the goal setting program was applied, however this was less evident for those gymnasts who were less motivated towards success. Kirkby and Kolt (1999) examined the motivation of 280 Australian gymnasts and 103 Chinese gymnasts. Participants were asked to complete a version of the participation motivation questionnaire. The comparative analysis of results suggested a cultural difference in motivation factors between the two populations. From an individual point of view, Lambert, Moore and Dixon (1999) investigated perceptions of motivation in gymnastics training. The authors examined the differential effects of self-set goals in comparison to goals determined by the trainer, according to the type of motivation. This study was based on two gymnasts with intrinsic motivation and two gymnasts with extrinsic motivation. They were exposed to conditions of self-determined motivation and conditions created by the coach. The authors concluded that motivation will be higher if goals are self-determined. In addition, Halliburton and Weiss (2002) examined the relationship between motivation and sources of information on competence using 103 intermediate level female gymnasts. They concluded that the perception of a climate of control is associated with the use of self-referenced sources of information and that the perception of a climate of performance is associated with the use of the comparison between pairs and the scores obtained in competition. Finally, a series of studies from Weiss and Weiss (2003, 2006, 2007) analyzed the factors which motivated female gymnasts at an intermediate and elite level. Global and specific research was carried out on between 124 to 304 gymnasts using questionnaire. These studies conclude that (a) the profiles of the gymnasts are similar but not identical to the predictions and that it would be desirable to differentiate the social, motivational and behavioral variables, (b) that the role of the parents and the coach seems central for attraction-entrapment, (c) engagement indicators enable a difference to be established depending on age and level.

Learning process

Eight articles contribute to this research area. Lufi, Porat and Tenenbaun (1986) sought the

psychological indicators of competitive performance of young male gymnasts (N=56). Two groups were made up (28 with high potential and 28 with low potential, which was determined after taking a test which took place at the end of one month's practice). Results showed that those with high potential reacted better to frustration, showed greater persistence, less ego defense, and had a more internal locus control. Swinnen, Vandenberghe and Van Assche (1986) aimed to examine the relationship between the cognitive styles concerning dependence/independence, reflection/impulsiveness and the acquisition of a driving skill in an unstructured training environment. Sixty-five girls and 57 boys aged 13 years were tested on a gymnastic performance. It was hypothesized that the independent subjects would do better in an unstructured training environment than the dependent subjects, however, this was only confirmed for the boys. In addition, other researchers have been interested in structured training and the effects of this training on the temporal nature of verbal instructions and the demonstration at the start of training complex figures in skating. Haguenaer et al (2005) tested 18 beginners on a vault by dividing the group into three (verbal instruction, metaphor and control group) following demonstration of the task by an expert and a 15 minute training session. Results suggested that performance modifications were related to the demonstration and the repetition task. Providing verbal instructions at the beginning of training did not have any effect. Robazza and Bortoli (2004, 2005a & b) and Robazza & al. (2007) set up acrobatic and balance tests aimed at analyzing the factors intervening between individual differences, acrobatics and balance. After verifying the internal validity of the tests, they undertook a study on 72 male high-school students during 12 lessons. This study measured the effect of acrobatic practice in physical education on the idiosyncratic management of the emotions of participants presenting approach-avoidance signs. The tests revealed that an education in acrobatics made it possible for participants with strong avoidance to change their attitude towards adventure sports. With a view to assist training, Baudry, Leroy and Chollet (2006) tested the assumption that video will lead to an improvement of gymnastics pommel horse performance. The study focused on 16 promising gymnasts who completed a series of two circles on the pommel horse with the greatest possible amplitude. The study concluded that the video feedback group improved their alignment to a significant degree. Conclusions were that the use of video feedback can contribute it to the correction of complex movements like these circles. However, its effectiveness was in connection with the complexity of the phase circle. It was concluded that videos provide an aid in the construction of a cognitive representation of the movement. Within this framework Hars and Calmels (2007) have also shown that when training of an acrobatic figure, most gymnasts will focus on spatial information (i.e., one or several part of the body) and not on kinematics.

Anxiety and Self-confidence

Six articles make up this research theme. Lee and Hewitt (1987) studied 36 female gymnasts (beginner-level and intermediary level) with anxiety levels which ranked from high to low. The group was divided into three sub-groups. They were asked to practice the mental representation of their gymnastic exercise, some on a small mattress, others in sensory insulation boxes and others stood still, forming a control group. The variables taken into account were the average scores obtained during three competitions and the gymnasts' self-evaluation of their physical state. The results showed that the group who had practiced the mental representation exercises in the sensory box had better performances and evaluated physical disorders as less important. Tremayne and Barry (1990) examined the psychological and physiological effects in accordance with level of anxiety and repression (Davis & Schwartz, 1987). The study used 16 female gymnasts to observe differences in tonic physiological measurements associated with differences in the states and/or of the levels of anxiety. The authors then examined whether similar differences were associated with differences in the levels of repression. Their results showed that the level of repression does not have an influence on the features of anxiety, thus raising questions about the validity of repression in this context. There were, however, small effects suggesting that repression can affect components of the attention process in various situations. Another study carried out by Crocker and Leclerc (1992) aimed to test the validity of a model of confidence in high-risk diving among 40 beginners (men and women). The data showed that confidence in the performance of the dive was directly related to the perceived feelings of pleasure, skill, and perceived risk. Further, Kerr and Goss (1997) studied self-control using a sample of 30 young female gymnasts. Psychological measurements were carried out using The Nowicki-Strickland Locus of Control Scale for Children, the Coopersmith Inventory Coil-Esteem, and the Spielberg State-Feature Anxiety Inventory for Children. Results indicated that the gymnasts had a higher external locus of control and lower self-esteem score than indicated from existing literature on the norms for this age and gender. However, they also observed that the features of their anxiety were the same. Research has also examined the effects of psychological interventions on gymnastic performance. Fournier & al. (2005) tested the effects of a psychological skills training (PST) program on psychological performance and indicators such as relaxation, mental representation, goal setting and visualization. This study used 21 female gymnasts who were divided in two groups; 10 participants using the PST program and 11 without the program over a 10-month period. The authors concluded that the PST program was more effective on the psychological indicators on three apparatus, bars, beam and floor. The 10 gymnasts who had followed the program increased by 5% more than those who had not followed the program.

Further research has examined competitive performance anxiety in gymnastics. Cottyn et al (2006) measured anxiety during a competitive beam performance by eight national level gymnasts. The authors monitored heart rate and used retrospective self-reports of nervousness during one competition and two training session. Three conclusions were made: (a) there is a negative correlation between self-reported score and heart rate during a routine, (b) there were no significant differences on the self-report scores in the three sessions observed, (c) heart-rate was higher during competition than during practice. The results demonstrated the potential value of retrospective report of nervousness and discussed this in relation to catastrophe theory.

Imagery

Five articles are included in the research data for this theme. Early research by Nishida et al (1986) validated a test of controllability of mental images (CMI) among a group of male and female gymnastics students (n=279). The aim of this test is to check the handling of mental images and the ability to control these images. The authors concluded that this test was valid but future research was needed to allow it to be generalized. Grouios (1992) observed the effects of mental practice on diving performances using 30 participants. Results indicated that mental practice can significantly affect performance ($p < 0.1$) by facilitating sensory feedback. Calmels and Fournier (2001) aimed to measure the potential difference between the actual duration of a routine and the mental duration using 12 high level female gymnasts. The assumption was that there would be a lengthening of the duration according to the perception of the difficulty of the lifting skill. Results suggested that the speed of visualization depended on the conditions of the gymnast and the value that they assigned to visualization. If these conditions are verified, the tendency to increase mental time according to the level of difficulty would be proven. Calmels et al (2003) have also shown that high-level gymnasts developed strategies differentiated from imagery to manage their emotional states, to evoke action and to produce a performance. Further research from Calmels et al (2006) extended this work in the field of neuron-imagery. This study aimed to examine the internal functional equivalence of imagery, the external image and the execution of action. 16 elite gymnasts carried out a complex vault performance (10 with an internal perspective, six with an external perspective). However, results did not provide support for the principle of temporal functional equivalence.

Developmental effects of training and performance in acrobatics sports

Two research clusters make up this theme: first, research which has examined how the practice of acrobatics makes it possible to develop athletes resources (e.g., postural information) second, research that is interested in the syndromes and problems encountered by the athletes in practice.

Syndromes, injury and disturbances

Eleven articles are included in this research area. One sub-theme of this area is Lost Move Syndrome. Day, Thatcher, Greenlees and Woods (2006) examined the psychological causes and consequences of this specific phenomenon in acrobatics. The syndrome was proposed to emerge from difficulties encountered by gymnasts during the take-off of the skill and from the training of skills. Semi-structured interviews were carried out with 15 trampolinists. Inductive content analysis led to the description of 54 causal explanatory topics (e.g., difficulty of acquisition of a skill, anxiety prior to take off, fear of disappointing the coach) grouped into sub themes (e.g., trainer athlete relation, pressure to come up with better results) until the obtaining of eight general dimensions. The results showed that even when skills had previously been successful then the training environment could be one potential cause for the emergence of this syndrome. In this research, certain athletes reported their skill learning as easy and fast. It was therefore proposed that this rapid skill acquisition may have made the skill more susceptible to Lost Move Syndrome. Other participants reported their skill acquisition as difficult and slow. It was proposed that this "disjointed" or dissociated processes of training (i.e., not allowing a sufficient construction to establish patterns) may also have led to skill loss. Research has also examined the psychological antecedents of gymnastics injuries. Early research from Mace, Eastman and Carroll (1986) studied the course of a young teenage gymnast who resumed training after a series of accidents and followed a program of eight sessions of mental skills training aimed at increasing his confidence and replacing negative self-images with more positive ones.

Results compared questionnaire data from the beginning of the program and at the end of the program, suggesting an improvement in self-esteem. These results were also corroborated by the trainer who reported an improved attitude and a fast progression in the acquisition of skills. Kerr and Minden (1988) also examined gymnastics injuries using 41 national level female gymnasts with ankle injuries caused by floor exercises and 20 coaches. Participants were asked to complete a questionnaire (integrating the psychological variables of Coddington Life Vent Record; Coddington, 1972) for two years preceding the accident. The results suggested that stressful events which preceded the period could be associated with the severity of the injury, although this did not correlate anxiety, locus of control, and self-concept. In addition, Mace et al. (1989) tested a relaxation program of imagery on 18 female gymnasts and a group control by measuring cardiac accelerations caused by stress. The authors concluded that there were no significant differences between two groups. A number of studies have focused on competition-related injuries (Kolt and Kirkby, 1994). Kolt et al. (1995) examined the psychological factors which were reported by 115 gymnasts following competitive injury.

Results from the POMS-BI and CSAI-2 showed that the most injured gymnasts had higher anxiety and were, in general, more tired. Female gymnasts were found to have higher anxiety, lower general confidence, and increased tiredness and confusion. Later research by Kolt & al. (2004) recruited 20 national and international gymnasts to examine the effects of a stress control program on injury. A longitudinal analysis over nine months separated the group into two subgroups, one group who took part in the program and another who formed the placebo group. The authors concluded that the program has had little effect on stress and injury but that conclusions on the effectiveness of the program were restricted by the small sample size. Chase, Magyar and Drake (2005) examined female gymnasts' psychological strategies and the perception of their effectiveness to overcome fear of injury. Ten female tumblers aged 12 to 17 (who had sustained a knee injury during their competitive career or during practice) took part in individual structured interviews. Results suggested that to overcome fear of injury mental preparation strategies (imagery and relaxation) were used by gymnasts. Cartoni, Minganti and Zelli (2005) examined the relationship between anxiety, personal effectiveness and the fear of injury according to age, gender and qualification level. Six hundred and eighty Italian gymnasts answered three types of questionnaires. The self-efficacy for physical abilities scale (Barberini & Robazza, 1996), the Trait Anxiety questionnaire (Busnelli, Dall'Aglio & Faina, 1974) and the Gymnastics Fear Inventory (Cartoni & al, 2005). Results established that on average males were less anxious and more effective. Gender showed no difference regarding fear of injury. Three studies have examined how psychological disturbances are managed by gymnasts. The first aimed to understand the perceived effects of emotions on athletic performance. Robazza, Bortoli and Hanin (2006) used the IZOF to determine the idiosyncratic emotions in relation to the physical symptoms experienced by 16 female and 19 male practicing professional ice-skaters and gymnasts. The results underlined a broad difference between individuals on the content of the emotions perceived during their performance and the impact of these emotions on the level of the physical symptoms experienced. However, there was also a relationship between emotions and corporal effects. The second study (Hauw & Durand, 2007) showed the value of taking the athletes' point of view into account in order to improve the understanding of mistakes made by trampolinists. Ten high level trampolinists took part in the study which was based on the "course of action" (Theureau, 2003) methodology. The authors identified zones of disturbance on which they could intervene to correct the errors which escaped the extrinsic analysis. Finally, the third study examined the underlying properties of stress in sport (Thatcher & Day, 2008). This research aimed to evaluate eight environmental properties proposed to underpin stress appraisals (novelty, predictability, event uncertainty, imminence, duration, temporal

uncertainty, ambiguity and timing in relation to the life cycle) using 16 national level trampolinists. Semi-structured interviews were used to focus on stressful experiences in competition. Conclusions were that all the suggested underlying properties of stress were present and relevant to the sporting domain. Further, two other properties were present (self and other comparison and Inadequate Preparation) which may be specific to the sporting context.

Posture

Three articles characterized the research data on this theme. Marin, Bardy and Bootsma (1999) measured the effects of interaction on expertise in gymnastics, the type of surface, and the necessary frequency of the movements of the head on the emergence of the modes of postural coordination. A group of female elite and a group of non-gymnasts were compared. The results suggested that imbalances are more important for the non-gymnasts. Danion, Boyadjian and Marin (2000) have tried to determine first how gymnasts are affected by the suppression of vision at the time of simple movements and second, which sensory signals exist for gymnasts having their eyes banded. Eight expert gymnasts and eight sporting experts were asked to maintain a straight displacement on three standards of locomotion (with eyes banded): (a) walking, (b) carting a wheel chair, (c) giving verbal orders to another person for them to push the wheel chair. The participants deviated in all the situations. However, with the exception of the verbal condition, the gymnasts were closer to a linear movement than the control group. The authors concluded that even for a simple driving task, the performance of the gymnasts deteriorated with a loss of vision. They also showed that compared with other sportsmen, gymnasts remained stable in the absence of vision when the proprioceptive signals were available.

These conclusions led to two possible explanations: (a) that gymnasts are readily able to seize essential information (b) the proprioceptive system of a gymnast is more sensitive. Gautier, Thouwarecq and Chollet (2007) aimed at improving comprehension of the postural regulation by analyzing an arbitrary posture, the reversed handstand. Male participants aged 18 to 25 years, all of national and international level in gymnastics, were asked to carry out a balance on parallel bars. The authors measured the influence of peripheral vision and anchoring of central vision on the balance of the gymnasts from an ecological point of view. The study concluded that postural regulation may be considered as an emergent phenomenon.

Discussion and conclusion

Overall, the studies included in this analysis show an important evolution in the way psychological mechanisms are applied to acrobatic performance. Despite the diversity of themes, it is possible to identify three great acrobatic designs from an epistemic point of view.

The first design is known as "morpho kinetic" conception (e.g., Cadopi, 2005, Paillard 1971) on the one hand this implies a representation of the form prior to the actual action, and on the other hand an adequacy between the feelings of is the movement and the visual image of what the athlete wants to do. An example of this research theme is Calmels & Fournier (2001), in which the actual acrobatic performance is comparable to the realization of patterns driving in a stable environment. It places control and stability at the heart of the questions having to do with the psychological processes implemented at the time of the performances. The stress is laid on the part played by the system of data processing in the production, the regulation and the training of the movement. (Schmidt & Lee, 1999). The concept of driving program becomes a privileged conceptual framework which leads to define acrobatics as a closed skill (e.g., Higgins & Spaeth 1972). The representations would have a physical reality, a symbolic system and semantics. In this approach, acrobatics lie in movements projected in space receiving their instruction from an internal model. Within this framework, cognition guides and orders the action. A second theme is apparent in the number of studies which include perception and action. There are two identifiable orientations. The first orientation proposes that the situation and the action are linked and that cognition will not be central (Kelso, 1995). An example of this orientation are the studies of Martin & al (1999).

The concept of "affordance" supports the assumption of a utility given to the context whose acrobat could size upon to act. The links made between perception and action are direct, without any intervention of consciousness. The situation is conceived as a resource, an opportunity to act, and the acrobat adapts to this offer. The second orientation proposes that there are constraints that will weigh on the organization of the action according to a certain number of degrees of freedom (Bernstein 1967). The research of Delignieres et al (1998) is typical of this orientation. This orientation considers that there is "repetition without repetition" (i.e., each time a vault is made, the degrees of freedom of the acrobat are modified to adapt to the environment even if the general form remains the same). These studies can be grouped under the generic term "emergence". The behavior or cognition of the acrobat is not regarded as a central component in the control and regulation of acrobatic performance. In this approach cognition is regarded as a secondary variable. The situation in relation to the action plays the role of resource or constraint for the acrobat. The third design, known as situated cognition (Robbins & Ayedede, 2009), is articulated in the reflections of Varela (1988, 1991) on the systems known as autopoietic. Those studies focused on the embodied character of cognition as well as the co-determination of the action, cognition and the context. Research such as Hauw et al. stresses the meaningful level of organization of acrobatics' performance in a singular context.

The comparison between various disciplines makes it possible to understand the direction which the acrobats grant to their actions, identifying differences in their own perception or cognition during action while they perform seemingly similar skills (e.g., a back flip in gymnastics and a back flip in skiing). This research takes into account instability and introduces the viability of the activity which, from the acrobat's perspective, allows performance. Research on stress and Lost Move Syndrome provided by Day et al. also enriches reflections on this contextual effect. In conclusion, research on the psychological processes implied in acrobatic performance is distributed on a loop which makes it possible to understand the variations in the level of acrobatic performance. This research loop goes from the evocation of external causes either with or without consciousness awareness (e.g., first and second design) with the focusing of an intrinsic dynamic to the action and with participation of the pre-reflexive level of consciousness or experience (e.g, third design). The most frequently analyzed acrobatic activities are diving, trampolining, tumbling, and artistic gymnastics. Research on "freestyle" disciplines such as acrobatic skiing has

made it possible to give to increase the validity of the various models proposed. A second research loop may also be identified demonstrated by the skills researched from simple skills to more complex (from analysis of parts to analysis of the whole). However, in order for research to be applicable to acrobatic trainers and teachers the perspective of the acrobat in a particular context as well as from an external point of view must be considered. Following our analysis future research directions can be indicated. Research has examined the differences between an expert and beginner acrobat such as the psychological characteristics of the performance, but how one passes from beginner to expert has not been explained.

Consequently research should be concerned with acrobatic training and its impact on performance blocks such as LMS. Further, research which aims to understand the meaning given to situations by the acrobat would improve the ability of the coach to direct the behavior of the acrobat and possibly to eliminate mental blocks. Finally the development of research in acrobatic performance needs to enhance the links between sports science as a research domain and applied coaching practice.

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PSIHOLOŠKI PROCESI UKLJUČENI ZA VRIJEME AKROBATSKIH IZVEDBI: PREGLED

Sažetak

Akrobatska izvedba omogućava naročito bogati kontekst za istraživanje u sportskoj znanosti. Aktualno, veći broj publikacija o akrobatskim izvedbama je predstavljeno u područjima poput biomehanike, psihologije i traumatologije. Međutim, u stvarnosti, ne postoje istraživačke sinteze koje su promatrane iz psihološke domene. Cilj ovog članka je pregled literature o modelima i empirijskim istraživanjima povezanim s psihološkim procesima uključenim u akrobatske izvedbe. Ovaj pregled pokazuje poboljšanje znanstvenih spoznaja u sportskoj psihologiji na akrobatsku praksu. Prateći pretragu literature pronađeno je 66 članaka koji kombiniraju akrobatske izvedbe i sportsku psihologiju. Ovi su članci induktivno analizirani kako bi otkrili tri glavne istraživačke teme: a) organizaciju izvedbe, b) pripremu izvedbe i c) transformaciju subjekata akrobatskim vježbanjem. Ti članci su pregledani i izvedene su sugestije budućim istraživanjima.

Ključne riječi: akcija, saznanje, kontekst, elitna izvedba, akrobatika, sportska psihologija

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