LOAD EFFECTS OF FAST LONGITUDINAL ROTATIONS

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Pirouettes, jumps in figure skating and twisting somersaults are fascinating movements in sports. But there is a lack of investigations in the field of motor control and load effects of fast longitudinal rotations. The purpose of the present study was to analyze load effects during and after longitudinal rotations. A "Longitudinal Rotation Simulator", posturography, and video nystagmography were used to analyze the rotational load. Six gymnasts, eleven figure skaters, and nineteen non-athletes were investigated. There were significant differences in the postural control between gymnasts and non-athletes. Per-rotatory nystagmus amplitude was significantly lower after three rotations than after ten rotations. The posturography and the video nystagmography are valid methods to characterize the rotational load.

KEY WORDS: longitudinal rotation, postural control, vestibulo-ocular reflex.

INTRODUCTION: Rotations around the longitudinal axis are basic movements in some kinds of sports and dance. Pirouettes in figure skating, rhythmic gymnastics, and dance are a well-known example for such movements. Jumps in figure skating (Salchow, Axle, Lutz, Toe loop, Rittberger etc.) as well as twisting somersaults in gymnastics and diving are also movements with longitudinal rotations. Analyses of jumps in figure skating and twisting somersaults in gymnastics, acrobatics, and trampolining showed an increase of angular velocity in the last years (Knoll, Knoll & Koethe, 2000). In Table 1 the current level of angular velocity for these kinds of sports is summarized.

Table 1. Maximum of angular velocity around the longitudinal axis [deg/s].

Sports discipline	Twisting somersaults	Jumps with twists
Diving	1350	
Gymnastics	1200	
Acrobatics	1500	
Trampolining	1600	
figure skating		2100

The highest angular velocity (2100 deg/s) was analyzed in a quadruple Salchow in men figure skating and in a six twisting somersault (1600 deg/s) in men trampolining. Naundorf & Krug (2001) reported load effects of fast longitudinal rotations. In this study figure skaters had to perform ten longitudinal rotations on a special rotational apparatus at approximately 500 deg/s. Using posturography testing parameters (Winter 1990; Caron et al. 2000; Winters & Crago 2000) it could be shown that the postural sway was significantly higher after longitudinal rotations than before. The evaluation was based on the data subdivision in period of landing, regulation and stability. The results of longitudinal rotations confirmed the study of the same authors on load effects of somersault rotations (Naundorf & Krug, 2000). Tweed (1994) described the vestibulo-ocular reflex (VOR) as a phenomenon of rotational movements. Stangl, Fetter & Gollhofer (2000) investigated athletes in several kinds of sports concerning the spatial-dynamic precision of the VOR. These authors reported that trained athletes were able to suppress this reflex in all of the three rotational directions. However, in this study the angular velocity was relatively slow (100 deg/s). Summarizing the reported results, there is a lack of studies, which investigate motor control and load effects of movements with fast longitudinal rotations. Dance coaches have already used for a long time the so called "headspot-technique". Using this technique the dancer orients himself for a short time in the pirouettes on a fixed point (striking object). In diving, coaches have discussed the teaching of spotting in back and reverse somersaults (De Mers, 1983a, 1983b). But the usability of the "spotting technique" is disputed until today.

The current investigation was directed at two objectives of fast longitudinal rotations with angular velocity higher than 800 deg/s:

1. Analyses of load effects before and after the rotational movements by postural control,
2. Analyses of load effects during and after the rotational movements by per- and postrotatory nystagmus (nystagmography during and after rotational movements).

METHODS: The investigation of the load effects of longitudinal rotations were carried out on a "Longitudinal Rotation Simulator" (LRS). This simulator was integrated into a measuring system. The measuring system was configured with a force plate (Kistler, Typ 9261A), a video camera and a computer for data recording (see Figure 1). Using posturography, the force components F_x, F_y, F_z and the moment components M_x, M_y were registered. The center of pressure (COP) was calculated. The time of recording was 30 s at a sampling rate of 300 Hz. The data analysis based on the procedure by Naundorf (Naundorf & Krug, 2000).

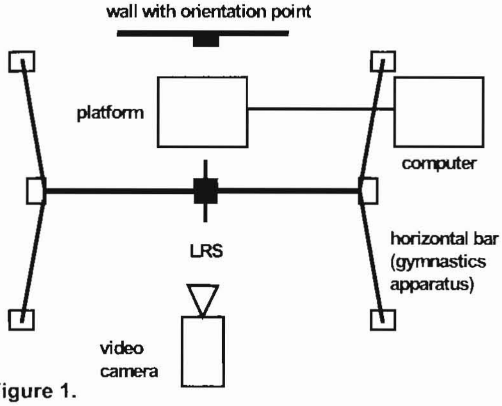

Figure 1.

The eye movements were recorded and analyzed with the video nystagmography system 2D-VOG (SensoMotoric Instruments). The system was based on an infrared camera, which was integrated with a completely blinded diving goggle (Figure 2). The per- and postrotatory nystagmus of the athlete's left eye was recorded. The video nystagmography signal was wirelessly transmitted to the computer-aided measuring system. The horizontal and vertical eye movements were recorded, and the amplitude, frequency, slow phase velocity of the vestibular nystagmus, and attenuation factor were evaluated by the software VN 15. All parts of the equipment (video camera, LRS, and video nystagmography) were synchronized. Similar to the recording of the chair velocity in clinical tests, the velocity of the LRS was registered.

Figure 2. Nystagmography system.

In the first part of the study six elite femal gymnasts (age: 10 - 14 years, mass: 36.13 ± 1.81 kg, height: 148.13 ±3.31 cm) and five non-athletes (age: 11 - 14 years, mass: 44.20 ±14.82 kg, height: 150.60 ±3.71 cm) participated. The subjects were rotated both in the preferred and non preferred direction. The amplitude and the duration of sways of the COP before (pretest) and after (posttest) five rotations were calculated using posturography. The question of this study was to test differences of the vestibular-spinal reflex reactions between both groups before and after fast longitudinal rotations.

In the second part of the study 11 elite figure skaters (age: 11 - 17 years, mass: 46.30 ± 11.13, height: 156.10 ± 8.02) and 14 non-athletes (age: 10 - 15 years, mass: 37.36 ± 9.47, height: 150.29 ± 11.47) participated. As previously, the subjects were also rotated in the preferred and non preferred direction, first 3 rotations, then 10 rotations (see Figure 3). For statistical analysis the software package SPSS 10.0 was used. Paired samples and independent samples of non-parametric distribution were analyzed by statistical tests according to Wilcoxon and Mann-Whitney. In the first part of the study both directions were analyzed separately.

Figure 3. Athlete on "Longitudinal Rotation Simulator" (LRS).

For the second part, a data pooling of the left and right side reactions was used.

RESULTS AND DISCUSSION: The results and discussion are focused on selected parameters. For the non-athletes, the amplitude of sways of the COP was higher than for the gymnasts (see figure 4).

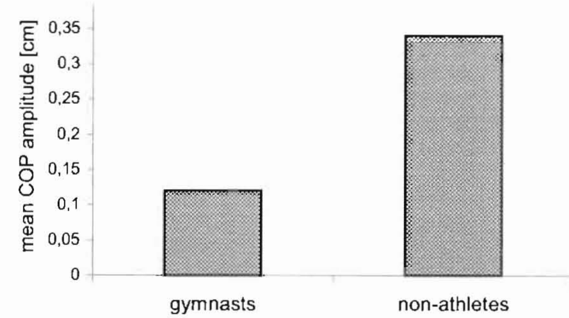

Figure 4. Comparison of the mean COP amplitude.

The inferential statistical analy-sis showed significant differen-ces in the regulation of the postural control between gym-nasts and non-athletes. For example, amplitude of sways of the COP for the gymnasts reached significantly lower values compared to non-athletes, both in pretest (U = -3.890; p<0.001) as well as in posttest (U = -3.693; p<0.001). Concerning the pretest (U = -3.099; p<0.01), significant differences were only noticed in the duration of sways of the COP. The results showed that training in gymnastics leads to an improved postural control in contrast to non-athletes. There-fore, the results found by Stangl, Fetter & Gollhofer (2000) are supported, since they found considerably lower angular velo-cities using clinical methods of investigation.

In the second part of the study, mean nystagmus amplitude was lower for both directions after three rotations than after ten rotations (see figure 5). In a further step it was shown that there were significant differences between the number of rotations (left: T = -3.251; p<0.01 and right: T = -2.770; p<0.01). There were no group specific differences between gymnasts and figure skaters. The nystagmography during fast rotations had the character of a pilot study. The analysis of the per-rotatory nystagmus showed high frequent reactions during fast rotations. The reactions of figure skaters were higher than gymnasts and divers. Further investigations are necessary to explain this phenomenon.

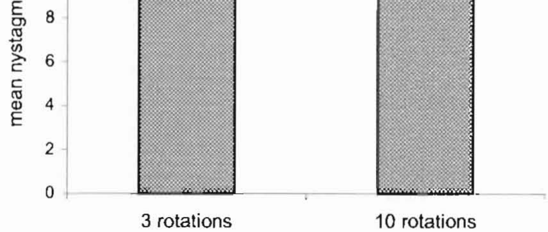

Figure 5. Comparison of the mean nystagmus amplitude.

CONCLUSION: In summary, posturography and video nystagmography are valid methods to characterize the rotational load. The combination of the "Longitudinal Rotation Simulator" and adapted clinical diagnosis methods can be used in the field of high performance sport. There were a lot of nystagmographical and postural reactions during and after fast longitudinal rotations. High levels of individual and group specific differences were found. It seems that, in contrast to non-athletes, training in gymnastics and figure skating leads to an improved vestibulo-spinal and vestibulo-ocular habituation. However, what constitutes an appropriate training program to get this positive effect has yet to be determined. The main benefit of these results could be a fast regaining of sport-specific demands on vestibulo-spinal and vestibulo-ocular habituation after a longer interruption of training, or an aimed instruction of unskilled athletes. Future studies should commence to extend the practical benefit of the results found in the present study.

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