

KNEE INJURIES AT LANDING AND TAKE-OFF PHASE IN GYMNASTICS

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Abstract

The purpose of the present study was to record the incidence of knee injuries in Greek artistic gymnasts in relation to the event and exercise phase. Two hundred artistic gymnasts aged 12.2 ± 2.8 years from different clubs of North and South Greece volunteered to participate in this study for the 2010-2012 seasons. Authors twice a week registered any injury occurred during practice or event which made the gymnast miss the next practice or event session. Results showed that gymnasts sustained 49.5% of knee injuries in landing mainly in the floor routines causing ligament sprains with these injuries to be occurring at the pre-competition season, usually during training time. Furthermore, knee injuries at take off phase (11.9%) occurred mainly in the vaulting horse on forward rotation exercises on the first competition level. Conclusively, coaches mainly must use supplementary soft mats during training to restrict pressure on knee joints on landing phase and control the amount of jumping in an effort to reduce the possibilities to increase knee injuries, especially in this particular age group gymnasts.

Keywords: *Gymnastics, Risk Factors, Injury Prevention.*

INTRODUCTION

Sports injuries are phenomena with variable interaction of risk factors. Every incident that had as a result to deprive the athlete of his/her competence in Artistic Gymnastics (AG) to follow a part of his/her training or contest, was defined as an injury (Caine et al., 1989). Injuries such as those that occur in AG generally result from the culmination of a pre-existing condition

and/or a particular set of circumstances (Meeuwse, 1994). The answer to what causes sports injuries has rarely been studied (Lysens et al., 1984). 55-65% of injuries in AG that occur on the lower extremities are related with high repetition frequencies, with 50-70 % of lower limb injuries occurring on the tibiotalar and knee joints (Arampatzis et al., 2003; McNitt et

al., 1993). Numerous studies support that the most injured body parts in AG are the lower extremities (Andrish, 1985; Bak et al., 1994; Hunter & Torgan, 1983; Hutchison & Ireland, 1995; Kolt & Kirkby, 1999; Pfister et al., 1985), especially in ankle and knee joints (Bale & Goodway, 1990; Garrick & Requa, 1980; Kerr & Minden, 1988; Petrone & Ricciardelli, 1983; Tenvergert et al., 1992).

Most injuries are related with landing (Kirialanis et al., 2002; Lindner & Caine, 1990; McNitt-Gray et al., 1994; Meeusen & Borms, 1992; Panzer, 1987; Verhagen et al., 2000). This phase not only affects the final rank of gymnasts during competition (Leskosek et al., 2010), but also entails a high risk of injury, mainly due to the high impact magnitudes of 14 to 18 Body Weight applied to one leg (Panzer, 1987), and to the mat's instability (Arampatzis et al., 2002, 2003). Landing imposes forces on the body that must be absorbed primarily by the musculoskeletal components of the lower extremities. If the loads become too great for the body to accommodate, a potential injury situation arises (Dufek & Bates, 1990). Drawing programs with exercises for good landing in gymnastics, separated from the all routine, would help to decrease impact forces during landing (Gervais, 1997). Takeoff and land are important phases in gymnastics routines. Previous studies showed that the magnitude of impact forces tends to increase with the skill complexity and with the increase of falling height (Karacsony & Cuk, 2005; Marinsek, 2010; McNitt-Gray et al., 1994; Panzer, 1987), ranged from 3.9 to 14.4 times the gymnast's body weight (BW) (McNitt-Gray et al., 1993; Panzer, 1987). Take off also is a phase used primarily in the vault, floor exercise and balance beam (BB) exercises. The take off imposes forces on the body, primarily in the musculoskeletal components of the lower extremities. Takei (1989) reported that the average horizontal and vertical forces during periods were 2970 N, which translated into 4.9 times the BW of the subjects. In addition, forces at takeoff at different somersaults can be up to 13.9

times the participant's BW (Karacsony & Čuk, 2005). Thus, the large changes in knee and hip joints in the range of motion (ROM) suggest that these joints play a greater role than the ankle in adjusting to landings (McNitt-Gray, 1991). However, there is lack of studies about the risk factors causing injuries during these two phases. The purpose of this study was to investigate the risk factors for the knee injuries especially during landing and takeoff phase in AG.

METHODS

Subjects. Two hundred artistic gymnasts (100 males and 100 females) (aged: 12.2 ± 2.8 , years, mass 35.6 ± 11.2 kg, height 141.5 ± 15.8 cm,) from different clubs of North and South Greece volunteered to participate in this study. Authors twice a week registered any injury that occurred during practice or event which made the gymnast miss the next practice or event session.

Statistical Analysis. An analysis of correspondence was used after an analysis of frequencies to estimate the relation between the criterion variables and the predictor variables for gymnasts.

RESULTS

From the analysis of frequencies, gymnasts sustained 49.5% of knee injuries in landing and 11.9% in take off. Analysis of correspondence revealed that three factors explain the total variance of the depended variables included in the analysis. The eigenvalues and the percent of variation explained by each factor are presented.

The first factor was created by the depended variables related to the take off (blocking) (Table 2) and the depended variables related to the training characteristics (strength training – flexibility training-warm-up etc).

The second factor was created by the depended variables related to the take off and variables related to the landing (Table 3).

The third factor was created by the depended variables related to the take off and variables related to the fall. (Table 1).

It is evident that knee injuries from landings mainly occur during backward saltos particularly in the floor exercise causing ligament sprains. Moreover, the time of rehabilitation lasts more than 2 months, in most not “selected” gymnasts sustained one injury in the knee over the season (for the competition gymnastics). In the side of the first and third factor axes, where are located the take off (blocking) are loaded the variables of table 3.

As it turns out from table 3, knee injuries at take off phase occurred mainly in the vaulting horse on forward rotation exercises (forward saltos), and they are presented to the first competition level (beginners: ages 7-10 for boys and 7-9 for girls), in not “selected” gymnasts and they did not need medical care, due the fact that the duration of rehabilitation was less than one month.

From the analysis of correspondence for the relation between the phases at which occurred the knee injuries and the predictor variables as risk factors resulted two factor

axes which interpret the 80.5% of total variation.

By table 2, it is realized that knee injuries at the landing occur at the pre-competition season, usually during training time, when the training duration is more than four hours a day and the repetition of elements on the vault is more than twenty. Knee injured gymnasts present re-injury and first aids are usually given by a physiotherapist. Also, variables that are related to the knee injuries at the landing are the lack of safety and spotting equipment e.g. springboard tumbling, foam pits which reduce up to 50% peak vertical ground reaction forces (VGRF) (Daly et al, 2001; Wilson et al, 1989). Landing at the competition season under normal conditions without using thick and soft landing mats and not practicing special landing elements can be a risk factor for knee injuries.

In the side of the first factor axis where are located knee injuries at the take off, the variables that are loaded usually occur during training time, when the training duration is more than 2-4 hours daily, and the repetition of taking off is more than 30 times in a training day (table 3).

Table 1
Eigenvalue % of variance and % Cumulative variation

Factors	Eigenvalue	% of variance explained	Cumulative variation
1 st factor (take-off - other)	0.077	38.21	38.21
2 nd factor (landing-take-off)	0.072	35.79	74.00
3 th factor	0.0527	26.00	100.00

Table 2

Variables that are included in the side of factor axes where are located knee injuries due take-off

Variables	Coordinates	Absolute attendance	Relative attendance
Age of beginning training 3,4, 5 years	0.30	7.1	0.95
Vault	0.44	5.7	0.26
Exercises with front rotation (front saltos)	0.35	6.4	0.74
Re-establishment in less than 1 month	0.14	1.2	0.62
1 st competition level (young - boys 7-10 and girls 7-9 years old)	- 0.49	11.8	0.99
Non selected	- 0.13	2.1	0.25
No medical treatment	- 0.36	5.5	0.49
Training 2 until 4 hours	0.67	5.7	0.63
Injuries at training time	0.04	0.1	0.18
Above 30 vault elements	0.19	1.3	0.23
They afterwards continued training after injury	0.08	0.4	0.62
Does not exist re-injury	0.17	0.7	0.26

Table 3

Variables that are loaded in the side of factor axes where are located knee injuries due landing

Variables	Coordinates	Absolute contribution	Relative contribution
Not selected gymnasts	0.22	4.2	0.70
One time injured	0.15	2.4	0.72
Floor	0.22	4.5	0.63
Sprain of ligaments	0.30	4.5	0.90
Time of rehabilitation > 2 months	0.51	11.0	0.43
Backward rotation (backward salto)	0.35	8.6	0.82
First aids from physiotherapist	0.30	3.1	0.72
Training above 4 hours	- 0.23	2.8	0.32
Lack of foam pits	- 0.48	1.4	0.42
Lack of spring floor	- 0.15	1.4	0.15
Injuries at the training time	- 0.05	0.3	0.31
Injuries at preparatory period	- 0.10	0.7	0.76
Landings out of foam pits at the competition period	- 0.24	1.4	0.31
Not used lading mat	- 0.27	2.2	0.56
Not using special landing exercises	- 0.23	4.2	0.84
20-29 vault elements daily	- 0.50	9.0	0.70
Re-injury	- 0.11	0.5	0.94

DISCUSSION

Knee injuries concerning the phase of injuries. Our results that came from take-off (49.5%) and landing (11.9%) are in agreement with previous studies (Bak et al., 1994; Garrock & Requa, 1980; Gervais, 1997; Hudash & Albright, 1993; Hunter & Torgan, 1983; Kirialanis et al., 2003; Pettrone & Ricciardelli, 1987; Readhead, 1987; Tauton et al., 1988) which support that the repeated jumps and landings at dismounts can cause problems in young gymnasts.

Knee injuries at landing. The analysis of equivalences revealed that the greater number of knee injuries at landing occurs during floor exercise. This finding reinforces data of Linder and Caine (1990) which report that 40% of the injuries happened in floor exercise, in erroneous movement and from a lack of the body control at the phase of landing. Also, it was shown by the results that when gymnasts are landing at the competition period outside of foam pits without using thick landing mat, it influences the appearance of knee injuries.

Ligament sprains at the knee during landing are the most common injuries that occur usually after exercises with back rotation and particularly during landing after back somersaults, result that verify previous data (Caine et al., 1989; Vergouwen, 1986). Also, Andrish (1985) supports that ligament sprains have the second place as for the frequency but are the most serious and they need surgical attention.

It is realized that knee injuries at landing are more serious than ankle injuries as a result of the longer time for rehabilitation (2 vs 1 month for knee and ankle injury, respectively) and despite that a lot of knee injured gymnasts tried to continue training after the injury; they presented re-injury. Perhaps, this it is owed to the complexity of the knee articulation and to the Special Forces where it accepts the knee at the landing. With this ascertainment agree findings of Bos and Sol (1982), which report that landing during

exercise on the vault and after dismounts, can cause big forces in the ankle joint and particularly in the ligaments. Another factor which contributes to an increasing in the frequency of a knee injuries at the landing includes the number of hours spent training daily (> 2-4 hours daily for the knee injuries and > 4 hours daily for the ankle injuries). No reports exist particularly for the knee injuries at the landing in relation to the duration of training. However, the duration of training has been incriminated by the researchers weekly (Pettrone & Ricciardelli, 1983) generally for knee injuries in gymnastics (Bak et al., 1994; Caine et al., 1994). Also, another external factor that seems to affect the appearance of knee injuries at landing is the lack of certain spotting apparatus like tumbling floor, foam pits.

Our results are partly equivalent with reports of Goodway et al (1990), which support that in gymnastics teams that had fewer safety equipment, more injuries occurred, whereas Lowry and Le Veau (1982) support that the presence of safety equipment does not ensure that they will be used. Meeusen and Borms (1992) report that various spotting equipment are used for the protection from various injuries, emphasizing however that it constitutes question for investigation how much it really happens. On the contrary, other studies (Pettrone & Ricciardelli, 1983; Weiker & Ganim, 1982), did not find a significant relationship between injuries and safety equipment. However, Wilson et al (1989) found that peak VGRF reduced by 50% with the use of a mat and sprung floor, compared with a mat placed directly on a concrete floor. Daly et al (2001), in their review report that no formal controlled studies have evaluated the effectiveness of matting, sprung floors, padded vaults, or other protective devices suggest that safety devices and protective equipment are designed to reduce the magnitude of impact

forces imposed on the musculoskeletal system and thereby the potential for injury.

Gymnasts who are not using special exercises for landing during the “training season” and involve a great number of repetition of jumps (>20 jumps daily in vaulting horse) increase the probabilities of knee injuries, a finding that was confirmed by the value and relative attendance at the analysis of correspondence.

The lack of relative reports limits the documentation of ascertainment in the present research on the particular relation. It was realized that non selected gymnasts present more possibilities to be injured in knee joint at landing, compared to selected gymnasts. This ascertainment may be explained by the fact that gymnasts that are selected have certain special characteristics such as special somato-type, small height and body mass (Caine et al., 1989; Claessens et al., 1991), and specific physiologic characteristics such as strength and flexibility (1990). Nevertheless some researchers have characterized certain characteristics as risk factors that affect the appearance of injuries such as higher height and weight (Steele & White, 1986).

Knee injuries in landing phase correlated with the young gymnasts (boys 7-10 years and girls 7-9 years). In this critical age, the knee joint should not be burdened with such a great number of repetitions combined with the length of training spent daily. The results strengthen the opinion that knee injuries at landing or take off phases in gymnastics occurred to the children who are starting gymnastics from an earlier age (3-5 years old) and they usually affect young gymnasts in the competition level (boys 7-10 and girls 7-9 years old). It is common for a gymnast to start training at the age of five or six years (Dixon & Fricker, 1993). Daly et al. (2001) suggest the majority of participants in gymnastics are children and this is probably because of the widely held belief that to achieve success at the highest level, training and competition should begin before puberty.

Knee injuries at take off. Our results support that takeoff influences mainly the

appearance of ankle injuries. Some of the gymnastics apparatus like the vault for the knee injuries at takeoff seems to have a greater risk of injury than the other apparatus. No previous studies have examined the relation between the incidents of knee injuries at the take off and in the gymnastics apparatus they appear.

According to McAuley et al. (1987) the few injuries that are observed in vaulting could be, because of the small time spent on this apparatus, a finding that opposed those of Vergouwen (1986), which report that most injuries occur on vault. From the results of analysis of equivalences did not result particular type of knee injuries at the take off. There is not exists particular report in the probability of knee and ankle injuries at take off, that would argue this suggestion. This can be explained by the fact that in floor exercise and vault apparatus executed, the most important role is played by the ankle joint. The particularity of the step in the spring board, or the ankle at take off, causes the calf muscles to act more than any other muscle. Because these jumps are repeated many times, tendinitis is created, particularly in the Achilles tendon, which needs a long time and particular care for the right rehabilitation. Taunton et al (1988) agree that the repeated jumps can create injuries in new athletes of gymnastics but the most frequent type in these cases are apofysitis and the illness of Osgood. Contrary to the appearance of injuries at the landing, where more serious problems are created in the knee, the phase of take off isn't as serious for the knee injuries. The time of training (2-4 hours) and the big number of takes off (> 30) in a daily unit training affect the appearance of knee injuries at this phase.

Our result, are in congruence with other studies which shows that the great number of takes offs leads to the appearance of injuries (Hudash & Albright, 1993; Tauton et al., 1988). Finally, it is realized that the “selection” is not only factor that determines the athletic career but it also plays an important role in the likely appearance of injuries, which can be interpreted from the

fact that “selected” gymnasts will have the suitable mobility, characteristics and fitness, which for some number of researchers constitute risk factors that affect the appearance of injuries (Ekstand & Gillquist, 1983; Meeusen & Borms, 1992; Micheli, 1985; Steele & White, 1986).

CONCLUSIONS

Coaches must mainly use supplementary soft mats during training to restrict pressure on knee joints during the landing phase. Further, a strict control and recording of the amount of exercises that is performed during daily training must be done in order to regulate the progressive volume of training, especially in this particular age group of gymnasts.

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