Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

KINETIC PROFILE AND INCIDENCE OF INJURIES AMONG HIGH PERFORMANCE TRAMPOLINE GYMNASTS

S. M. Kuisis[1], T.C. Camacho[2], S. M. Dafel[1] and D. C. Janse van Rensburg[3]

University of Pretoria, Institute for Sport Research, Pretoria, South Africa[1]
University of Pretoria, Department of Biokinetics, Sport and Leisure Science, Pretoria, South Africa[2]
University of Pretoria, Section Sports Medicine, Pretoria, South Africa[3]

The purpose of this study was: a) Determine the differences among injured and non-injured trampolinists with regard to kinetic data collected; b) Determine if there were any associations between the type of injuries sustained and the kinetic data collected. A one-year retrospective analysis of kinetic test results and medical records of a group of high performance trampolinists was performed. Fifteen participants between the ages of 10–20 participated in the study (9 males and 6 females). 40% of participants sustained an injury for which they sought medical advice. The incidence of injury per 1000hours of trampoline use was 2.3. Injured trampoline gymnasts had significantly lower range of motion of the left ankle and total work values for the left dorsiflexors. Coaches, gymnasts and parents should be educated about the potential risks and take measures in preventing injuries.

KEY WORDS: Peak torque, range of motion, total work.

INTRODUCTION: Trampoline gymnastics was accepted and recognised as an Olympic Sport in 2000, despite the seriousness of trampoline injuries documented in the literature (Larson & Davis, 1995). Knowledge of lower quarter strength can be useful in the prevention, conditioning and rehabilitation of injuries in trampolining. Therefore the purpose of this study was to a) Determine the differences among injured and non-injured trampolinists with regard to kinetic data collected; b) Determine if there were any associations between the type of injuries sustained and the kinetic data collected

METHODS: A one-year retrospective analysis of kinetic test results and medical records of a group of high performance trampolinists was performed. For the purpose of this study "high performance trampolinists" is defined as gymnasts who engage in more than 10 hours per week of trampoline – specific training and who represent South Africa. Fifteen participants between the ages of 10 – 20 years (mean age = 15.7±3.4 years) participated in the study (9 males and 6 females). Prior to the study all participants were provided written informed consent and were informed of the objectives of the testing protocol. They were instructed to give maximal effort in all the tests they performed. Before each test the researcher demonstrated the execution of the test to the participants.

Anthropometric measurements: Each participant's stature (cm) and mass (kg) was measured using standardized equipment. Seven skinfolds were measured using a Harpenden skinfold calliper; ten girth measurements were recorded using a flexible tape measure; and six diameter measurements were recorded using a Life Max sliding calliper. The sites measured and the procedures used were in accordance to the guidelines stipulated in MacDougall, *et al* (1991). The Heathe-Carter method was used to determine predicted body fat percentage (% BF) and lean body mass (LBM). The Drinkwater – Ross method was used to determine predicted percentage muscle mass (% MM) and percentage bone mass (%BM). Body Mass Index (BMI) was calculated using the standardized formula (kg/m^2).

Isokinetic tests: The Cybex Norm™ isokinetic dynamometer was used. The tests conducted were knee flexion and extension at 60º/sec (5 repetitions) and 180º/sec (15 repetitions); ankle plantarflexion and dorsiflexion at 30º/sec (5 repetitions) and 120º/sec (15 repetitions). The guidelines stated in Cybex Norm™ Testing and Rehabilitation Systems (1996) were used for the dynamometer and participant set up. Prior to testing a five minute warm-up was performed on a cycle ergometer, followed by 5 minutes of stretching. 4 trial repetitions before testing at each velocity were given. Participants were instructed to give maximal effort with every repetition.

Table 1
Mean Biographical and Anthropometric data for All Participants (n=15)

Variable	Mean±Standard Deviation
Age	15.7±3.4 years
Stature (cm)	160.1±10.8
Mass (kg)	50.7±11.2
BMI (kg/m^2)	19.5±2.3
% BF	18.6±5.7
% MM	42.3±4.4
% BM	18.4±2.7
LBM (kg)	41.1±9.0
Preferred side	Right

Table 2
Mean Isokinetic Variables for all Participants (n=15)

Knee flexion/ extension	Right	Left	Deficit
60°/sec Quadriceps (Nm/kg)	240±57	247±40	8±6
Hamstrings (Nm/kg)	130±28	141±126	12±8
180°/sec Quadriceps (Nm/kg)	164±29	167±28	5±3
Hamstrings (Nm/kg)	98±19	100±16	10±11
H:Q ratio (%) at 60º/sec	55±5	57±6	
H:Q ratio (%) at 180º/sec	60±6	61±11	
Range of motion (°)	106±4	106±6	
Total work ext	1350±455	1333±436	
Total work flex	751±277	749±230	
Ankle plantarflexion/ dorsiflexion			
30°/sec Plantarflexion (Nm/kg)	220±45	216±48	13±10
Dorsiflexion (Nm/kg)	59±15	51±14	14±12
120°/sec Plantarflexion (Nm/kg)	117±30	116±38	18±12
Dorsiflexion (Nm/kg)	43±12	37±12	22±16
P:D ratio (%) at 30º/sec	27±8	25±8	
P:D ratio (%) at 120º/sec	38±13	34±11	
Range of motion (º)	55±8	53±9	
Total work plantarflexors	415±150	426±236	
Total work dorsiflexors	131±38	97±36	

Statistical Analysis: Descriptive statistics were used to determine the mean and standard deviation for the variables measured. Scores for the whole group and for the injured and uninjured groups were determined. The Mann-Whitney U-test was used to determine the differences between the injured and uninjured groups. Alpha was set at a minimum of $p \leq 0.05$ (significance, for all result differences, was set at the 5% level of significance) (Howell, 1992). *Definition of injury:* Any condition sustained during practice or competition that necessitated the complete cessation of participation in practice or competition; and/or required treatment from a doctor. *Injury Incidence:* This was calculated in relation to exposure-time and thus expressed as injuries per trampoline training hours (the number of trampoline training as numerator and number of injuries incurred as denominator). The trampoline hours were calculated as the product of the total number of trampoline training hours per season and the number of injuries during that time, as well as the number of injuries per 1000 trampoline training hours, with the number of injuries as the numerator and the exposure time (per season) as the denominator, multiplied by 1000.

RESULTS AND DISCUSSION: Participants dedicated 11 hours per week to trampoline specific training and 2 hours per week to strength and conditioning training. 40% of the participants (n = 6) sustained an injury for which they sought medical advice. There were 13 injuries recorded (5 = males; 8 = females). The highest incidence of injury occurred in the age group of 14 to 18 years. The incidence of injury per 1000 hours of exposure to trampoline training was 2.3, and one injury occurred for every 440 hours of exposure to trampoline training. This was higher than the 1.4 injuries per 1000 hours of exposure that Kajer & Larsson (1992) reported for figure skaters and lower than the 3.4 to 4.6 injuries per 1000 hours exposure in endurance sports (running and rowing), contact sports (soccer), non-contact sports (tennis, gymnastics, basketball), and explosive sports (sprinting and long jumping) (Bonner *et al.* 2003).

Table 3
Location, number and type of injuries, age group and gender

Location	Type of injury	# injuries	Age Group (yr) 13-15	16–18	19 +	Gender M	F
Foot	Heel pain	3	2	1		1	2
	Forefoot pain	1	1				1
	Inflammation	1			1		1
	Great toe sprain	1		1		1	
Ankle	Grade 1 talofibular ligament sprain	1		1		1	
Calf	Grade 1 muscle tear	1		1		1	
Knee	Sinding-Larsen-Johansson syndrome	1		1		1	
	Jumpers knee	1	1				1
Thigh	Partial quadriceps tear	1			1		1
Back	Sponylolisthesis	1		1			1
Elbow	Panner's disease	1	1				1
TOTAL		**13**	**5** *(39%)*	**6** *(49%)*	**2** *(15%)*	**5** *(39%)*	**8** *(62%)*

There was no statistically significant difference between groups with regards to the kinetic variables measured, except for the total work values measured for the left dorsiflexors and ankle range of motion of the left ankle. The injured group presented with significantly lower range of motion of the left ankle when measured by the Cybex Norm isokinetic dynamometer and lower total work values for the left dorsiflexors. Interestingly the statistically significant differences noted were on the non-preferred side of the trampoline gymnasts. These findings may have contributed to the injuries reported in this study.

Table 4
Differences among the injured group & uninjured group

Variable		Injured	Un-injured	Significance
Bone %		16.7±2.0	19.6±2.5	p<0.10
Muscle %		39.9±5.9	43.7±2.2	p<0.10
Left knee flexion peak torque (Nm/kg) 180º/sec		90.7±12.7	106±15.2	p<0.10
Knee flexion peak torque (Nm/kg) deficit 180º/sec		6.2±9.2	12.8±10.9	p<0.10
Ankle total ROM measured during isokinetic testing (º):	Right	49.4±6.3	57.3±6.9	p<0.10
	Left	46.4±8.4	57.3±7.5	p<0.05*
Left ankle plantarfexion peak torque (Nm/kg) 120º/sec		92.4±27.9	128.3±36.9	p<0.10
Left dorsiflexion total work (Nm)		66.8±22.8	114.4±29.9	p<0.05*

* Statistically Significant p≤0.05

Amongst the injured trampoline gymnasts 83% (n=10) of injuries involved the lower quarter. The most frequent complaints were heel, foot and knee pain. Malliaras, *et al* 2005 stated that as coupling between ankle dorsiflexion and eccentric contraction of the calf muscle is important in absorbing lower limb force when landing from a jump, reduced ankle dorsiflexion range may increase the risk of patellar tendinopathy. Kirialanis, *et al* 2011 reported that the large strain placed on the lower limb joints, especially the knee and ankle ligaments, during the floor exercise performed by artistic gymnasts, increases the risk of injury to the lower limb joints. This study reported two ligament sprains in the foot and ankle in two male trampoline gymnasts. Repetitive training regimens are associated with pathologic lesions at the tendinous junctions, tendoperiosteal attachments, and immature epiphyseal plates (Dubravcic-Simunjak *et al* 2003). The force absorbed by the knee extensor mechanism during landing contributes to the development of anterior knee pain and overuse injuries (Dubravcic-Simunjak *et al* 2003). This may manifest as jumper's knee and Osgood-Schlatter disease, one of which was reported by a female trampoline gymnast in this study. The current study did not report any bone fractures or injuries to the cervical spine, despite them being the most commonly reported injuries in studies concerning injuries and the recreational use of the trampoline (Ansah & Sella, 2000; Brown & Lee, 2000; Black & Amadeo, 2004).

CONCLUSION: Trampoline is a high risk activity. Coaches, gymnasts and parents should be educated about the potential risks and the measures taken in preventing injuries (Larson & Davis, 1995; Dubravcic-Simunjak *et al* 2003). Good technique, adequate flexibility, and sufficient strength are basic requirements for the athletic components of trampolining. Physicians and rehabilitation therapists should provide guidance on injury prevention and care as well as monitor the training of trampoline gymnasts. Due to the small number of participants used in this study further research is recommended to corroborate the findings of this study.

REFERENCES

Ansah, M., & Sella, E. J. (2000). Treatment of complete open medial subtalar dislocation with external fixateur: a case report. *Foot & Ankle Surgery,* 6, 179-184.

Black, G. B., Amadeo, R., & Surg, C.J. (2004). Orthopaedic injuries associated with backyard trampoline use in children. *Journal of Paediatric surgery,* 39(4), 653.

Bronner, S., Ojofeitimi, S. & Rose, D. (2003). Injuries in a Modern Dance Company. *American Journal of Sports Medicine,* 31(3), 365-373.

Brown, P.G. & Lee, M. (2000). Trampoline Injuries of the Cervical Spine. *Pediatric Neurosurgery,* 32, 170-175.

Cybex Norm™ Testing and Rehabilitation Systems (1996).(pp 10-21). Ronkonkoma, New York: Cybex International, Inc.

Dubravcic-Simunjak, S., Pecina, M., Kuipers, H., Moran, J. & Haspl, M. (2003). The incidence of injuries in elite junior figure skaters. *The American Journal of Sports Medicine, 31(4), 511-517.*

Howell, D.C. (1992). *Statistical methods for Psychology* (3rd ed.) (pp 611-619). California: Duxbury Press.

Kajer, M. & Larsson, B. (1992). Physiological profile of and incidence of injuries among elite figure skaters. *Journal of Sport Science,* 10, 29-36.

Kirialanis, P., Malliou, P., Beneka, A. & Giannakopoulos, K. (2011). Occurrence of acute lower limb injuries in artistic gymnastics in relation to event and exercise phase. *British Journal of Sports Medicine, 37(2), 137 – 139.*

Larson, B.J. & Davis, J.W. (1995). Trampoline-related injuries. The *Journal of Bone & joint Surgery*, 77(8), 1174-1178.

MacDougall, J.D., Wenger, H.A. & Green, H.J. (1991). *Physiological testing of the High-Performance Athlete (2nd ed), (*pp 223-250). Illinois: Human Kinetics.

Malliaras, P., Cook, J.L. & Kent, P. (2006). Reduced ankle dorsiflexion range may increase the risk of patellar tendon injury among volleyball players. *Journal of Science and Medicine in Sport*, 9(4), 304-309.