Injury in the Australian sport of calisthenics: A prospective study

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The aims of this study were to determine the rate, anatomical regions, onset, severity, and type of injury in the sport of calisthenics and compare injuries reported by elite and non-elite participants. Prospective reports of injuries were collected over a 12-month period from 550 elite and non-elite calisthenics participants. The participants recorded the number of training sessions, competition, and performances per week, hours of training, and information on any injuries sustained each week during the survey period. Five hundred and fifty participants reported 190 injuries during the survey period, 0.4 injuries per participant year or 0.3 injured participants per participant year. The odds ratio of injury in the elite to the non-elite group was 2.0 (95% CI 1.3 to 2.9). Injuries to the lower back (32.4% of all injuries), hip thigh and groin (25.4% of all injuries) were most common. Activities involving lumbar extension (29.8% of all injuries and 61.0% of lower back injuries) were perceived by participants to have led to injury. In general, injuries were minor and mainly involved soft tissue structures (95.6% of all injuries). Participants had difficulty in identifying why their injuries had occurred. Calisthenics participants did not report high injury rates, but activities that involve lumbar extension are implicated in low back injuries and warrant further attention. **[Leaf JR, Keating JL and Kolt GS (2003): Injury in the Australian sport of calisthenics: A prospective study. *Australian Journal of Physiotherapy* 49: 123-130]**

Key words: Epidemiology; Gymnastics; Sports; Wounds and Injuries

Introduction

Calisthenics is a competitive sport, unique to Australia. It was developed originally from physical culture in Europe and America and incorporates skills from gymnastics and dance (Otzen 1988). From the Greek words "kalli" and "sthenos" for beauty and strength, (Delbridge et al 2001) calisthenics involves free exercises performed with varying intensity and rhythm with or without light hand-held apparatus (The New Encyclopaedia Britannica 2002). The apparatus includes clubs and rods manipulated by each participant. Calisthenics was an all-female sport from the 1940s to the year 2000, with children, adolescents and young adults training for local and national competitions in team and individual items. Competitors training for one annual national competition (classified as elite) are selected at audition by coaches accredited through the Australian Calisthenics Federation (ACF), the national governing administrative body of calisthenics.

Calisthenics participants, similar to those in all sports, risk injury (Backx 1996). While injury risk has been investigated in several high profile sports in Australia (Dixon and Fricker 1993, Kolt and Kirkby 1999, McKay et al 1996) no attention has been given to the lesser known sport of calisthenics. Research into injury in this sport is warranted because there are 15,000 registered calisthenics competitors in Australia (Australian Calisthenics Federation Incorporated 1998) and an additional unknown number of non-competitors. Epidemiological data regarding the number and types of injuries in calisthenics are needed to assess the risk of injury in this sport so that injury prevention strategies can be addressed. This is the first report of an investigation into injury in calisthenics participants.

Earlier epidemiological studies of injury in sport have predominantly used cohort (retrospective or prospective) or case-control designs. The latter does not permit the assessment of the incidence of injury in a sporting population. In a cohort design, a broad and representative sample of athletes is monitored and injury rates assessed (Meeuwise and Love 1997). Arguably the better type of cohort design is the prospective study as it decreases the dependence on participant memory (Twellaar et al 1996).

In light of the lack of research in the sport of calisthenics, the aims of the current study were to determine:

- the rate, anatomical region, onset, severity, and types of injury incurred by Australian calisthenics participants;
- the venue attended or personnel engaged to assess injury;
- the calisthenics event (training, competition or performance) during which injuries occurred most commonly;
- the activities and reasons perceived by participants to have contributed to injury; and
- the differences in injuries reported by participants training for national competitions (elite) and those training at the next highest level of competition, known as championship (non-elite) level.

Table 1. Age and training regimes of elite and non-elite calisthenics participants over the 12-month prospective survey period.

Competitor	Age		Training		
	Range (years)	Median (quartiles)	Range (hrs/wk)	Median (quartiles)	Range wks/year
Elite	6.3 - 27.2	12.5 (9.5 - 15.5)	3.1 - 9.8	6.7 (5.7 - 7.5)	30 - 52
Non-elite	6.5 - 30.0	12.4 (9.8 - 16.7)	3.0 - 8.5	4.7 (4.3 - 5.3)	29 - 50

Method

Subjects Subjects were 550 (303 elite and 247 non-elite) Australian female calisthenics participants. Elite competitors were members of all state teams for the survey year (1996): Western Australia, South Australia, New South Wales, Queensland, Victoria, and the Australian Capital Territory. Elite participants, defined by their involvement in the national competition, trained concurrently with a local club, in addition to state team training (an ACF requirement). The age and training times of participant are listed in Table 1.

The non-elite participants in this study, (ie those not training for the national competition), trained at four championship clubs in the state of Victoria, the highest level of competition within the state. To attain championship status, clubs had been ranked by Calisthenics Victoria Incorporated (CVI), the state governing body of calisthenics, using the results of competitions from the previous year.

In addition to weekly training sessions, elite and non-elite participants were involved in competitions and concerts.

Test instrument Participants were requested to complete a survey form, a training diary and, if injured, an injury inventory. The survey requested information on age, years of training, and the age that training commenced. The Calisthenics Injury Inventory (Appendix) was based on instruments used in previous studies (Finch et al 1999, Kolt and Kirkby 1995 and 1999). Item development incorporated expert opinion, items identified to be of value in instruments used in earlier studies and the inclusion of items specifically tailored for assessment of calisthenics injuries. To refine the instruments, a series of pilot studies were conducted and feedback obtained from pilot participants. Modifications were also made to reduce observed user difficulties. Using the injury inventory instrument, details were sought on the anatomical site, onset and type of injury, reason for injury, activity being performed when the injury occurred, the venue attended or personnel sought to assess the injury and whether the injury occurred at training, competition, or a performance. Injury severity was based on sessions of training, competitions, and performances missed and modified due to injury as in studies by Kolt and Kirkby (1995 and 1999). In a diary completed each week, participants recorded training times, including the number of sessions of training, competition, or performance, and hours of training. This allowed calculation of injury rates relative to exposure (de Loës 1997). Each exposure to a competition, performance, or training was recorded as one session. Each month, the diaries and injury inventories were collected by a designated supervisor and sent to the investigator. Supervisors were either a parent or assistant coach who volunteered, or was appointed by club managers, to oversee completion of the survey forms.

Injury was defined as physical harm resulting from a calisthenics activity and requiring the participant to miss or modify training, competition or performance. This definition was used in earlier investigations of gymnasts (Kolt and Kirkby 1995 and 1999) and was chosen because it provided information on a wide range of injuries (both minor and severe) that disrupt training. Participants and their parents were responsible for reporting when an injury occurred.

Procedure Approval for the study was received from the Ethics Committee of La Trobe University, and the ACF. All teams that were approached agreed to participate in the study (100% response rate). The primary investigator travelled to the Australian Capital Territory and to each state where calisthenics is practised (except one with no elite participants in the year of the study), to explain the survey in a standardised way to coaches, supervisors, participants, and parents. This was done to avoid individuals introducing interpretation bias into the implementation of the survey (Polgar and Thomas 1988). Reminder letters were sent to supervisors to promote participant compliance, a problem identified in pilot testing of this survey, and earlier prospective research (Twellaar et al 1996).

Of 650 participants involved in 10 clubs (six elite and four non-elite), 627 began prospective recording, a participation rate of 96.5%. Of these participants, 77 (41 elite and 36 non-elite) either failed to complete 12 months of data collection (13 elite and 15 non-elite), or left the sport (28 elite and 21 non-elite) during the survey period. Informally, club supervisors reported that two of these participants

Table 2. Injury rates for the total sample, elite and non-elite groups.

Incidence rates (95% CI)	Total sample (N = 550)	Elite (n = 303)	Non-elite (n = 247)
Participants injured per participant year	0.3 (0.2 to 0 3)	0.3 (0.3 to 0.4)	0.2 (0.2 to 0.3)
Participants injured per 1000 hours of training	1.1 (1.0 to 1.3)	1.2 (1.0 to 1.4)	1.1 (0.8 to 1.4)
Participants injured per 1000 sessions	3.0 (2.5 to 3.5)	3.0 (2.4 to 3.6)	3.0 (2.3 to 4.0)

Table 3. Comparison of elite and non-elite participants for rate and characteristics of injuries.

Injury characteristics	Chi square, Mann-Whitney and odds ratio (OR) analyses
Rate of injured to uninjured participants	OR 1.95 (95% CI 1.32 to 2.88) *
Anatomical region of injury	χ^2 (5, N = 185) = 0.82, p = 0.97
Type of injury	χ^2 (5, N = 183) = 7.04, p = 0.22
New or recurrent injuries	χ^2 (1, N = 185) = 1.40, p = 0.24
Sudden or gradual onset injuries	χ^2 (1, N = 180) = 0.20, p = 0.65
Personnel consulted for injury	χ^2 (5, N = 185) = 6.93, p = 0.23
Calisthenics events (training competition or performance) during which injury occurred	χ^2 (2, N = 182) = 4.45, p = 0.11
Reported activities at the time of injury	χ^2 (4, N = 181) = 0.60, p = 0.96
Reported causes of injury	χ^2 (5, N = 177) = 3.97, p = 0.55
Number of weeks of calisthenics missed due to injury	U = 3793, z = -1.13, p = 0.26
Number of weeks of calisthenics modified due to injury	U = 3931.5, z = -0.47, p = 0.63

*significant differences between training groups, $p < 0.05$.

(both non-elite) left the sport due to injury, one due to a dislocated knee, the other due to an unspecified foot injury. No information was available on the reasons for the other participants leaving the sport. The dropout rate was 12.3%.

Statistical analyses Statistical analyses were conducted on the number and types of injuries in the overall sample. In addition, the elite and non-elite groups were compared for differences in the number of injuries incurred, the number of injured participants per participant year, the number of injured participants per 1000 sessions of calisthenics (during training, competition, or performances) and the number of injured participants per 1000 hours of training. Injury rates for the two training levels were compared using the ratio of the odds of a participant being injured, and an incidence density ratio (IDR) for the number of participants injured per 1000 sessions, or per 1000 hours of training. The odds ratio is a measure of the difference in the likelihood of a participant being injured or not being injured depending on group allocation. The number of times any given participant is injured is not considered in the calculation. The IDR is an indication of differences between the number of participants injured in the two groups relative to the amount of exposure.

Data on injury characteristics were categorical, so chi squared analyses, including standardised residuals for each cell of the contingency table, were used to compare elite and non-elite groups.

Results

Overall, 550 participants reported 190 injuries over 51,191 sessions of exposure to calisthenics. These sessions were made up of 46,287 training sessions and 4,904 competition and performance sessions that took place over a 12 month period. Of 153 participants who were injured, 120 sustained one injury, 29 sustained two injuries, and four sustained three injuries. On average there were 0.4 injuries per participant and 27.8% of participants injured over the year of data collection. There were 3.0 injured participants per 1000 sessions of training, competition or performance and 1.1 injured participants per 1000 hours of training, excluding time spent at competitions and performances (Table 2).

There was a significant difference in the number of participants injured per participant year in the elite compared with the non-elite group. The odds ratio of a participant being injured compared with not being injured while training in the elite compared with the non-elite group was 2.0 (95% CI 1.3 to 2.9).

Table 4. Anatomical location of injury for the total sample, elite and non-elite groups.

Location of injury *	Total sample (N = 185)		Elite (n = 122)		Non-elite (n = 63)	
	N	%	n	%	n	%
Lower back	60	32.4	40	32.8	20	31.7
Thigh, groin, hip	47	25.4	32	26.2	15	23.8
Knee	27	14.6	16	13.1	11	17.5
Ankle, foot, lower leg	26	14.1	18	14.8	8	12.7
Upper limb	16	8.6	10	8.2	6	9.5
Other (eg neck, abdomen)	9	4.9	6	4.9	3	4.8

Number of injuries

*five participants failed to give details of the anatomical region of injury.

Table 5. Injury types for the total sample, elite, and non-elite groups.

Type of injury*	Total sample (N = 183)		Elite (n = 120)		Non-elite (n_= 63)	
	N	%	n	%	n	%
Muscle strain	88	48.1	58	48.3	30	47.6
Other (eg tendonitis, soft tissue combinations)	28	15.3	14	11.7	14	22.2
Ligament sprain	27	14.7	21	17.5	6	9.5
Unsure	17	9.3	11	9.2	6	9.5
Inflammatory conditions	15	8.2	12	10.0	3	4.8
Fracture, dislocation	8	4.4	4	3.3	4	6.4

Number of injuries

*seven participants failed to answer.

There was no difference in the number of participants injured per 1000 sessions between the two training levels when exposure to training, competitions and performances was considered. The IDR was 1.0 (95% CI 0.7 to 1.4). There was also no difference between the number of participants injured per 1000 hours of training in the two training groups when time spent at competitions and performances was excluded, IDR 1.1 (95% CI 0.8 to 1.5). Other injury characteristics were similar across the two training levels (Table 3).

In the total sample, the most common anatomical sites reported injured were the lower back and thigh/groin/hip region (32.4% and 25.4% of all injuries, respectively). When standardised residuals were assessed from the chi squared contingency table, both these regions appeared to be more frequently injured than other body parts, χ^2 (5, N = 185) = 59.9, $p < 0.001$ (Table 4).

Muscle strains (48.1% of all reported injuries) were the most commonly reported type of injury (assessed using standardised residuals), χ^2 (5, N = 183) = 139.5, $p < 0.001$. Other injury types are documented in Table 5.

When injuries were classified as new for the first occurrence or recurrent if the injury had been experienced previously there were more new (67.6%) than recurrent (32.4%) injuries reported overall, (χ^2 (1, N = 185) = 22.8, $p < 0.001$). More injuries were reported as sudden (58.3%) than gradual (41.7%) onset, (χ^2 (1, N = 180) = 5.0, $p = 0.03$). A "sudden onset" injury was where the transition from uninjured to injured was immediate, and "gradual onset" was assigned to an injury that developed over time (Wadley and Albright 1993).

More injuries occurred in the total sample during training (76.9%) than at competitions or performances (15.4%), or other circumstance (7.7% at home practice or unknown; χ^2 (2, N = 182) = 157.2, $p < 0.001$).

Injuries were more frequently assessed by physiotherapists than by other personnel, χ^2 (5, N =185) = 91.5, $p < 0.001$;

Table 6. Venue attended or personnel who assessed injury in the total sample, elite and non-elite groups.

	Number of injuries					
	Total sample (N = 185)		Elite (n = 122)		Non-elite (n = 63)	
Venue attended or personnel who assessed injury	N	%	n	%	n	%
Physiotherapists	71	38.4	54	44.3	17	27.0
Injury not assessed	45	24.3	24	19.6	21	33.3
Combination [1]	29	15.7	18	14.8	11	17.5
Other [2]	20	10.8	13	10.6	7	11.1
Medical practitioners	13	7.0	9	7.4	4	6.3
Sports medicine centre	7	3.8	4	3.3	3	4.8

[1] physiotherapist and medical practitioner, two or more medical practitioners.
[2] coaches, masseurs, chiropractors, myotherapists, and occupational therapists.

Figure 1. Tiger stand (left) and standing splits.

Table 6). Of note, 24.3% (33.3% for the elite group and 19.7% for the non-elite group) of injuries were not formally assessed.

Of all injuries reported over the prospective 12-month survey period, 22.6% were associated with missed sessions of calisthenics. Most injuries (97.4%), however, required participants to modify training, competition or performances. Of the 43 injuries where participants missed sessions of calisthenics, 67.5% caused participants to stop for one week, 30.3% for between two and three weeks and 2.2% required more than three weeks away from the sport. For 16.9% of injuries, time was taken off work or school.

Walkovers, backbends, standing splits, bridges, and tiger stands were the activities most frequently perceived by participants to have caused injury (29.8% of all injuries). Two of these activities are presented in Figure 1. These figures show the requirements of lumbar extension.

Participants appeared to have difficulty in providing a reason for injury. In 34.5% of cases, they were unable to specify why injury had occurred, and a further 23.0% described a variety of reasons that may have contributed to injury.

Discussion

Injury rates in calisthenics across Australia were 0.3 participants injured per participant year and 0.4 injuries per participant year when the definition of injury incorporated any injury leading to missed and modified training, competition or performance. More injuries occurred during training than at competitions or performances. The most common injuries occurred in the lower back, and hip, thigh and groin regions. Most injuries were described as affecting soft tissue structures. Injuries appeared minor and required minimal time missed from calisthenics or disruption to work or school. Injured participants primarily consulted physiotherapists for injury management. In general, participants had difficulty in identifying precise causes of injury.

This investigation into injury in calisthenics helps to establish information on the risk of injury in this sport. No other studies of calisthenics injury have been published.

A higher number of participants in the elite group reported injury compared with participants in the non-elite group within the study period. However, when training exposure was considered, no difference was seen between the two training levels. It seems that the additional hours of training per week of elite calisthenics participants accounted for the difference in injury rates between the two training groups.

Participants in calisthenics did not appear to have high injury rates. Over a 12-month period, 27.8% of participants were injured. The one comparable study that used the same definition of injury as the current study and prospectively investigated Australian competitive gymnasts (Kolt and Kirkby 1999), reported that 100% of gymnasts incurred an injury over an 18 month period (Kolt and Kirkby 1999). If the definition of injury had included only injuries that caused participants to miss calisthenics, 7.3% of participants would have reported injury.

Calisthenics participants reported high proportions of lower back injuries (32.4% of all injuries). Earlier studies of gymnasts reported that between 5.2% and 15% of all injuries occurred in the lower back region (Caine et al 1989, Dixon and Fricker 1993, Kolt and Kirkby 1995 and 1999, Lindner and Caine 1990, Wadley and Albright 1993). Dancers reported between 12% and 34% of all injuries occurred in the neck and back regions (Bowling 1989, Brinson and Dick 1996, Geeves 1990). Adolescent dancers reported between 12% and 17% of all injuries occurred to the spine (Geeves 1997). While some of the observed differences may reflect study design variations, Kolt and Kirkby (1999) used comparable survey methods and found that 14.9% of gymnasts reported injuries to the lower back region over 18 months. Hence it is likely that the rate of lower back injuries is high in calisthenics compared with dancers and competitive gymnasts.

Participants in this study perceived activities involving lumbar spine extension (eg walkovers, backbends, bridges, tiger stands and standing splits) as those that contributed most to injury, particularly to lower back injury. The apparent high proportions of injury to the lower back region in calisthenics participants may relate to the quality and quantity of lower back extension type activities performed in calisthenics. A reduction in the number of lumbar extension activities performed in training might lessen the likelihood of a lower back injury in calisthenics, as repetition of extremes in lumbar extension has long been proposed to cause back pain (Jackson et al 1976).

Like dancers (Bowling 1989, Brinson and Dick 1996, Geeves 1997) calisthenics participants sought treatment of injury primarily from physiotherapists. The reason for this could be that the majority of injuries in these disciplines appeared to involve soft tissue structures. Athletes may present to practitioners they are accustomed to seeing (Brukner and Khan 1993), or physiotherapists may be more readily acceptable to dancers because of their exercise approach to rehabilitation of injury (Geeves 1997). The same may be true for calisthenics participants.

In interpreting the findings of this study, the self-report nature of data collection should be considered. Despite the obvious limitations of this method (eg possible inaccurate recording of injury type), to achieve a nationwide involvement in this study that included 100% of elite competitors in Australia, methods such as injury assessment by medical practitioners were not viable. Nevertheless, almost two-thirds (64.9%) of all injuries were assessed by a medical practitioner or a physiotherapist and some participants reported diagnoses provided by medical personnel.

The current study is the first to investigate injuries in calisthenics. Three particular findings are highlighted.

Injuries in calisthenics are generally not severe. Those injuries occurring to the lumbar spine make up a high proportion of all injuries in calisthenics and this aspect needs further researching. When two training levels were compared, elite participants incurred a greater number of injuries than their non-elite counterparts, but the higher training hours performed by elite participants appears to provide the reason for the additional injuries reported in the elite group.

Acknowledgments Preparation of this paper was supported in part by an Australian Physiotherapy Association Victorian Branch Research Committee grant, and the Australian Calisthenics Federation. Thanks are extended to calisthenics participants and officials involved in the investigation, to Elizabeth Marshall for assistance in data entry and table formatting and to Lynne Hayward for permission to use the photographs in Figure 1.

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Appendix 1.

CURRENT CALISTHENICS INJURY INVENTORY

Please circle the number or tick boxes for each answer as appropriate NAME: ....

FILL OUT ONE FORM FOR EACH INJURY — FILL IN EACH BOX

DEFINITION OF INJURY IS — an injury that results from a calisthenics activity and requires the participant to miss or modify any portion of training, competition or performance.

INJURY ONSET	MAJOR PAIN REGION	TYPE INJURY	WHO ASSESSED/TREATED
Date of Injury: .... 1 New Injury 2 Aggravation of old injury **DID THE INJURY OCCUR** 1 Quickly (with one action) 2 Slowly (sore with certain movements over days or weeks)	1 Lower back 2 Upper back 3 Head 4 Neck 5 Abdomen 6 Shoulder 7 Upper arm 8 Elbow 9 Forearm 10 Wrist 11 Hand 12 Hip 13 Thigh 14 Knee 15 Lower leg 16 Ankle 17 Foot 18 Other List	1 Bruise 2 Skin cut 3 Fracture 4 Stress fracture 5 Strain/Muscle 6 Tendonitis 7 Sprain/Ligament 8 Dislocation/Joint 9 Inflammation 10 Other.................. 11 Unsure	1 Hospital 2 Sports Medicine Clinic 3 Doctor 4 Physiotherapist 5 No-one 6 Other........................ **DIAGNOSIS**........................ ....

WHERE INJURY OCCURRED	TRAINING MISSED OR MODIFIED DUE TO INJURY	
1 Class 2 Competition 3 Concert 4 Camp 5 Other - list	How many TRAINING days did you miss? How many sessions did you miss? How many TRAINING days were modified? How many sessions were modified?	Days .... Days ....

Which movement caused the injury? ....

....

Did you warm up before training? 5 minutes ❑ 15 minutes ❑ 30 minutes ❑ None ❑

Why did the injury occur? (i.e. insufficient warm up, fatigue etc.)..

....

Was any apparatus involved in the injury (i.e. rods/clubs)? Yes ❑ No ❑

If YES list ....

Did you miss any school or work? Yes ❑ No ❑ How long? Weeks .... Days ....

IF THIS INJURY WAS A LOWER BACK INJURY, PLEASE CONTINUE QUESTIONS

WHICH CALISTHENICS ACTIVITIES GAVE BACK PAIN? (You can circle more than one)		NON CALISTHENICS ACTIVITIES WHICH GAVE BACK PAIN INITIALLY (You can circle more than one)	INVESTIGATION
1 Walkovers 2 Bridge/Backbend 3 Chest raise from prone lie 4 Arabesque 5 Back trunk bend 6 Full forward bend	7 Head to legs 8 Bend forward in splits 9 Trunk twist 10 Trunk side bend 11 Other...........................	1 Sitting 2 Standing 3 Walking 4 Bending forwards 5 Twisting 6 Other .... 7 None	1 X-ray 2 Bone Scan 3 CT 4 MRI 5 Other .... 6 None

DIAGNOSIS (IF KNOWN) (Explain) ....

DID YOU HAVE ANY ASSOCIATED LEG PAIN WITH YOUR BACK PAIN? Yes ❑ No ❑

DID YOUR BACK PAIN OCCUR ***MORE*** WHEN YOU PERFORMED:- Backward bends Yes ❑ No ❑

Forward bends Yes ❑ No ❑

HOW MANY PAST EPISODES OF BACK PAIN HAVE YOU HAD IN THE LAST 3 YEARS? ....

DO YOU MINIMISE ANY CALISTHENICS DUE TO BACK PAIN? List ....