QUANTIFYING IMPACTS DURING BEAM AND FLOOR TRAINING IN PRE-ADOLESCENT GIRLS FROM TWO STREAMS OF ARTISTIC GYMNASTICS

Lauren A. Burt, Geraldine A. Naughton and Raul Landeo

Centre of Physical Activity Across the Lifespan, Australian Catholic University, Sydney, New South Wales, Australia

The primary aim of this study was to determine the effects of participation level (international and national), apparatus (beam and floor) and training phase (pre-competition and competition) on estimates of training load in a convenient sample of gymnasts aged 7 to 13 years. Video analysis of training sessions along with accelerometer and force platform (500 Hz) peak ground reaction force data were used to establish differences between key gymnastic-specific and non-gymnastic-specific variables. International level gymnasts demonstrated higher incidence in hours of training, number of observed impacts, markers of the quality of periodised training program and lower relative injury rates. Marked differences were also observed between the two training phases. The demand for injury prevention strategies may be higher at the national level of gymnastics training.

KEY WORDS: gymnastics, periodised training, impacts

INTRODUCTION:

Young gymnasts habitually undertake vigorous training programs of progressive volume and intensity from an early age for 12 months of the year. It is normal for talented gymnasts to begin training at five to six years of age and train between 20 to 30 hours per week (Caine, Bass & Daly, 2003a). Globally, gymnasts are becoming leaner and younger, while training programs are increasing in volume and intensity. The demand for more intensive training in young gymnasts combined with the decreasing age at which training begins, may create complications for the young female gymnast. Habitual exposure to gymnastics training involves impacts on various regions of the body and the risk of injury increases with training exposure (Caine & Nassar, 2005). The two apparatus involved with the highest injury frequency are the floor and balance beam (Caine et al., 2003b; Caine, Cochrane, Caine & Zemper, 1989; Kirialanis, Malliou, Beneka, Gourgoulis, Giotstidou & Godolias, 2002; Kolt & Kirkby, 1999).

The majority of previous research has focused on quantifying the level of impacts during one or more skills (Davidson, Mahar, Chalmers & Wilson, 2005; Seeley & Bressel, 2005) or has focused upon quantifying the incidence and severity of injuries (Caine, & Nassar, 2005; Caine, et al., 2003b). This study follows a multidisciplinary approach combining several research methods and links the research with training and competitive practice.

This study endeavors to advance the understanding of training load across two competitive streams of pre-adolescent gymnasts during the beam and floor apparatus in both competition and pre-competition phases of training.

METHOD:

Twenty-five gymnasts from an international [n = 12; age = 9.25 yr (± 1.86 yr); height = 1.30 m (± 0.10 m); mass = 27.66 kg (± 4.83 kg)] and national [n = 13; age = 9.77 yr (± 1.24 yr); height = 1.35 m (± 0.08 m); mass = 30.46 kg (± 5.23 kg)] levels program were assessed during two training sessions in both pre-competition and competition training phases on the balance beam and floor apparatus. Two 50 Hz digital video cameras (JVC GR-DVL820EA, Japan) recorded all the gymnasts' training on the beam and floor to determine the frequency of gymnastic-specific movements (e.g. landings). In addition, the vertical acceleration and total steps completed were quantified using a GT1M accelerometer (ActiGraph, LLC, model 5032, Fort Walton Beach, Florida) placed on the iliac crest of the right hip of each gymnast. The primary outcome variables were gymnastic-specific movements involving estimates of

ankle and wrist impacts (in which contact with the apparatus was less than one second), landings (contact with the apparatus for greater than one second), balance-related skills (any pose or hold maintained for greater than three seconds) and rotations (circular movements around any of the three body axes).

To further estimate training load, sixteen of the gymnasts (international $n = 8$ and national $n = 8$) performed additional beam and floor skills common to both groups on a Quattro Jump portable force platform sampling at 500 Hz (9290AD, Kistler Instruments Corp., Amherst, NY) to determine the peak vertical ground reaction forces (PGRF). The beam skills measured included the vertical straight jump, split jump, handstand, cartwheel and backward walkover. The floor skills included the jump full turn, split leap, round-off, back and forward handspring. The force platform was embedded within the floor area and was covered with a 0.10 m thick, FIG approved carpeted landing mat (Acromat, Australia). Pilot testing using rigid weight disks under both static and dynamic conditions, dropped from five different heights (varying from 0.555 m and 0.269 m) with and without the matting indicated that the PGRF were linear in response and therefore the error introduced to the GRF by using the landing mats was considered to be systematic (PGRF dampening: mean = 5.0 + 1.2%). The secondary outcome measures were training level, apparatus and phase.

Statistical analysis following tests for normality commenced with two-sample t-tests for differences between training level, apparatus, phase and baseline descriptive data using SPSS 12.0.1 for Windows (SPSS Inc., Chicago, Ill.). The effects of training level, apparatus and phase on gymnastics movements were then explored using intraclass correlations, three-way analysis of variation (ANOVA) and multiple linear regressions. Significance was set at $p \le 0.05$ for all analyses.

RESULTS:

The extent to which training level, apparatus or training phase explained variance in movement was skill-specific. Three-way interactions, were observed for ankle impacts [$F_{(1, 180)} = 18.925$, $p < 0.0001$] (Figure 1) and landings [$F_{(1, 173)} = 4.831$, $p = 0.006$] (Figure 2).
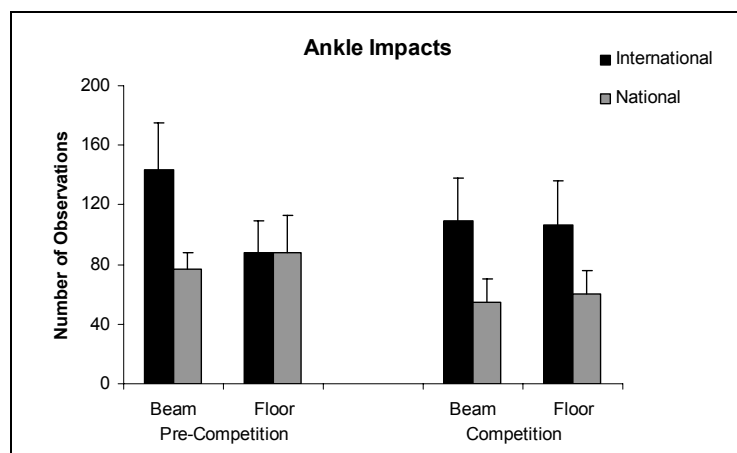

Figure 1: Number of observed ankle impacts on beam and floor apparatus in international and national level pre-adolescent gymnasts during pre-competition and competition phases of the periodised year.

Linear regression analyses were conducted following significant correlation coefficient effects. Explained variance was weak to moderate ranging from 34% to 51%. Therefore, other factors in addition to training level, apparatus and training phase must have influenced the dependent variables. PGRF scores were reported relative to body weight for selected beam and floor skills. Differences were not found between the ankle and wrist impacts of international and national gymnasts for any of the selected skills. Similarly, no differences were observed between beam and floor skills for the two groups. Group mean PGRF on the beam apparatus, ranged from 1.17 to 1.33 BW for the upper limbs and 1.80 to 5.59 BW for the lower limbs. Group mean floor apparatus PGRF applied to the upper and lower limbs varied from 1.99 to 3.99 BW and 3.30 to 8.46 BW, respectively. The floor apparatus routinely

exposed gymnasts to greater forces relative to bodyweight than the beam. Similarly, the lower extremity was exposed to greater PGRF than the upper extremity, across both apparatus.
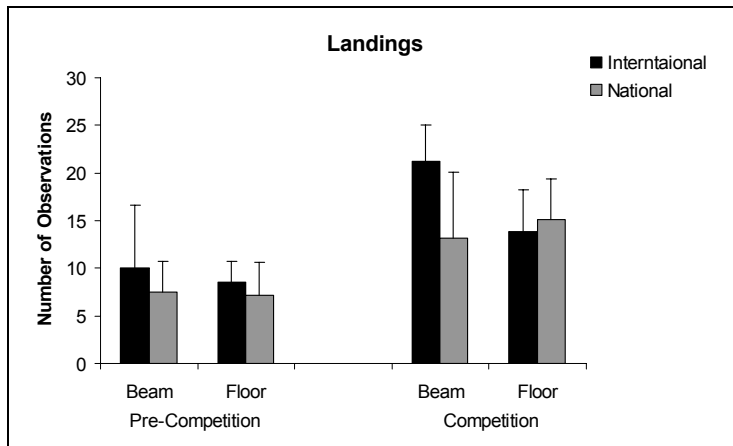

Figure 2: Number of observed landing impacts on beam and floor apparatus in international and national level pre-adolescent gymnasts during pre-competition and competition phases of the periodised year.

DISCUSSION:

The gymnasts' training level appeared to have the strongest influence on observed incidence of skills involving rotations and wrist and ankle impacts. International gymnasts, due to their advanced gymnastic ability, were able to link more skills on both beam and floor and therefore had a greater incidence of rotations and wrist and ankle impacts. The training phase also influenced the variability of observed ankle impacts, with higher occurrences during pre-competition compared to competition. Pre-competition was associated with increased ankle impacts due to the repetitive nature of this training phase.

The interaction effects between training level, apparatus and training phase may be due to the phase-related differences in the international level group, with more ankle impacts observed during the pre-competition than competition phase for beam. International level gymnasts also recorded fewer ankle impacts on floor compared to beam within the pre-competition phase, with similar frequencies across both apparatus during the competition phase. Among international level gymnasts, fewer ankle impacts on beam during the competition phase of training could be explained by more "whole", and less "part" practice. A higher incidence of connective dance elements in the competition phase of training for international gymnasts may explain observed differences between the two groups. Amongst international level gymnasts, observed landing frequencies increased for both beam and floor apparatus between the pre-competition and competition phases. Observed incidences almost doubled in beam compared to floor. Increases were also observed between the pre-competition and competition phases for national level gymnasts. However, the trends differed as the increases were greater on floor than beam.

The fact that both three-way interactions involved the lower limb relates dependent variance of ankle and landing frequencies. Differences between training level, skill and design within the periodised year became evident.

Two-way interactions were formed between training level and training phase and were significant for all dependent variables with the exception of accelerometer-determined accelerations. Further two-way interactions between training level and apparatus influenced observations of ankle impacts and skills involving balance. For example, competition involved more ankle impacts on the floor than beam, whereas pre-competition resulted in more ankle impacts on the beam than floor. The interaction effect may be explained by increased ankle impacts occurring on the beam during pre-competition compared to

competition, while negligible differences were observed between phases for ankle impacts on the floor. Increased rehearsal and part practices in the pre-competition phase may have generated more dismounts or falls from the beam which may account for observed differences between apparatus during this training phase.

CONCLUSION:

This study has shown that many factors must be measured and considered when evaluating injury risk and potential intervention strategies. International gymnasts were exposed to a higher frequency of impacts than national gymnasts across both apparatus throughout the periodised program. This effect is even more pronounced with the heightened hours of training each week associated with the higher skilled group. Coaches must be aware that frequent incidences as well as magnitudes of impacts lead to a greater need for injury prevention measures. The high mechanical loading of the lower body regions must be closely monitored to ensure the longevity of athletes and minimise the risk of chronic overuse injuries. In the present study, the international level gymnasts followed a more refined periodised training program. Markers of a quality periodised program, such as greater variation in training load (intensity and volume) between phases, maximise the opportunity for peak performance during competition and concurrently minimise the potential for overtraining or under recovery.

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