Executive Summary

Participation in gymnastics, along with swimming and athletics, forms an important part of a child’s physical education. Gymnastics participation can produce positive physical and psycho-social benefits for young people that, as a group of benefits, are not easily attained elsewhere. This paper collates current information about the benefits of gymnastics grouped under the three main headings of motor-skill benefits, fitness benefits, and psychosocial benefits. Like all physical activities participation in gymnastics presents risks as well as benefits.

Reported benefits from participation in recreational and competitive gymnastics are: enhanced development of most of the fundamental motor patterns, enhanced flexibility, enhanced strength and postural control, enhanced balance, enhanced anaerobic endurance, long-term bone forming and strengthening advantages, potential for enhanced academic readiness and cognitive abilities, enhanced task-mastery orientations, and enhanced skill focus and skill goal setting abilities.

One of the major benefits of gymnastics activity is that the gymnast's body experiences a wide variety of shapes, movement patterns, spatial changes and loadings (muscular and non-muscular) – all providing engaging and beneficial kinesthetic stimuli. Participating in gymnastics provides a unique movement experience not duplicated in any other human activity. In summary, it can be argued that gymnastics participation enriches and physically educates the lives of its participants in ways that are unreachable by most other activities and sports (68).
Introduction

Children move to bring order to the multiplicity of stimuli that pervade their lives, to control their physiology and, by extension, their environment. A child’s movement ability develops in a sequential manner moving from the very simple to complex movement patterns. The precise development of established rudimentary and fundamental movement patterns is essential for children’s growth and development (27).

Fundamental motor skills do not simply evolve, but must be learned (80). These fundamental motor patterns of stability, locomotion and manipulation encompass running, jumping, landings, rolling, hopping, climbing, throwing, and kicking. The mature coordination and specialized skills of adolescence and adulthood depend upon a planned acquisition of fundamental motor skills and associated fitness in childhood (28). A well-planned gymnastics experience at this time of the child’s life can extend the performance of these vital movement patterns, enhance key motor fitness areas, and enhance later stages of motor development. Traditionally, participation in gymnastics, along with swimming and athletics, forms an important part of a child’s physical education (16, 17).

An earlier, much cited article on the benefits of gymnastics (66) organized the benefits and limitations of gymnastics into the categories of physical benefits, psycho-social benefits, and miscellaneous benefits. In the last decade, little current information about the benefits of gymnastics has been reviewed. This paper seeks to update this topic.

Motor-skill benefits

Development of fundamental motor skills, postural control and motor coordination

Gymnastics is an excellent vehicle for the teaching basic motor skills and promoting health-related fitness in children of all ages (16, 17). The fundamental motor patterns that are best learned through a gymnastics education are: static shapes and static-dynamic balance, jumping & landing, rolling, turning & twisting, hopping, skipping & galloping, crawling & climbing, and stepping &
leaping (32). The gymnastics learning environment (via varieties of “fields of play” and apparatus) is unique in human movement in that it demands complex gravity defying body movements that require specific joint actions to be carefully aligned with the gymnast’s space, direction, time and rhythm (59). This may not be the case with other “game-based” activities that focus on narrow, yet important, aspects of the fundamental motor patterns (e.g. throwing & catching, hitting & kicking).

Historically, gymnastics has served an essential role in physical education and the development of physical fitness and can make significant future contributions to the goals of physical education (16). Coehlo’s (2010) article suggests that physical education teachers should be willing to explore and utilize a wide array of resources, instructional strategies, and assessment techniques to offer a complete, developmentally appropriate gymnastics program for students of all ages.

Several recent studies (7, 12, 18, 29) have investigated the influence of gymnastics training on motor coordination, postural control and proprioception. The first study investigated the possible effect of specific sports training on motor coordination and anaerobic power in 184 children from different sports (swimming, tennis, team handball & gymnastics). While the differences between sports in Wingate performance disappeared when the data were normalised to body mass, the gymnasts were the best jumpers and were pre-eminent in the more complex motor coordination tasks such as the drop jump (7). Studies have compared artistic and rhythmic gymnasts to other athletes in terms of their postural coordination. The most interesting finding in this study is that rhythmic gymnastics training seems to have a direct effect on the ability to maintain bipedal posture (14). The next findings showed that gymnasts’ proprioceptive system is more efficient than that of non-gymnasts, and that this may be the result of gymnastics training (18). The final study investigated the influence of gymnastics training on the postural control of children in age groups, aged 5-7 and 9-11 years old with and without the use of visual information. Younger gymnasts presented greater postural control with visual information compared to younger non-gymnasts (29).
**Gymnasts can learn to jump, land and fall safely**

Children who participate in gymnastics can learn to fall without injuring themselves (65). Gymnasts learn to jump, land, and fall during skill practice on matting and apparatus. Learning to jump, land, roll and fall helps gymnast avoid injury and can help prevent injuries in most sports. Gymnasts acquire a very "cat-like" ability to right themselves and to fall without being hurt (15, 64).

**Physical-Fitness benefits**

Gymnastics participation requires, and develops, a myriad of fitness abilities (51). These include a high level of local muscular endurance, strength, power, joint flexibility, co-ordination, speed & agility, balance, and a highly developed kinesthetic sense. Indeed, the variety of physical manipulations of the body that a gymnast will experience can be much greater than those of any other activity; the decathlon included (62). These physical demands and their outcomes have placed gymnasts among the leanest, strongest and most flexible of athletes (48, 51, 62, 69).

**Developing aerobic endurance and anaerobic endurance**

Gymnasts tend to have average levels of aerobic (with oxygen) endurance, and high to very high levels of anaerobic endurance (37, 44, 53). Gymnastics performances usually last under 120 seconds. The level of intensity of gymnastics activities can be high and the duration too short for the development of high levels of aerobic endurance as observed, for example, in long-distance running sports. However, most sports are anaerobic in nature. Anaerobic endurance means "without oxygen" endurance and this refers to the predominant use of in-muscle energy supplies to provide the necessary short bursts of muscle strength that must prevail in power sports such as gymnastics (52). Gymnastics requires, and therefore develops, high levels of anaerobic endurance.

Maximal (anaerobic) power output has been measured by the Wingate test in competitive male gymnasts at between 11 and 14 W.Kg-1 and in female gymnasts between 10 and 12 W.Kg-1.
(35, 44). These levels are at and above the 95th percentile. Measurement of higher blood lactate values also confirms that gymnastics activity has resulted in an increased anaerobic capacity (44).

While the goals and characteristics of gymnastics training seemingly contrast with engagement in cardio-respiratory health-enhancing physical activity, improvements in Moderate to Vigorous Physical Activity (MVPA) can be realized in gymnastics. Improvement in energy expenditure and developments of lean muscle mass can result when anaerobic activities of gymnastics are mixed with aerobic activities (26).

*Developing relative strength*

One of the major benefits of children’s participation in gymnastics compared to that of untrained peers and participants in other sports is enhanced strength (1, 8, 35, 48, 54).

Using a mixed longitudinal design, the development of flexibility and isometric strength of the upper and lower limbs was studied for 2 years in 453 young athletes (aged between 9 and 18 years) practicing football, gymnastics, swimming or tennis. Boys and girls in all sports were of similar strength up to around 11 years. Male gymnasts 12 years and older, who were still increasing their muscle strength up to 19 years, were significantly stronger than all other athletes (48).

Maximal voluntary strength of the trunk muscles was measured in 57 male athletes (soccer players, wrestlers, tennis players, and gymnasts), 14 female gymnasts, and in a control group of 87 conscripts. Strength differences were present between the athletes and the controls, some of which appeared to be sport specific and related to long-term systematic training. Male gymnasts were significantly stronger in hip flexion than all others; gymnasts as a group were quickest in hip extension, and female gymnasts were found to be superior to untrained males in hip extension (1).

General strength results for children tend to plateau and in some cases (e.g. upper body strength in females) decline in late adolescence and adulthood (35). Children need on-going exercise to develop “relative strength” before age, gender and experience based changes become
established. Gymnastics training provides an invaluable vehicle for this strength training in early childhood, late childhood and adolescence.

**Developing balanced posture and “core” muscular strength**

Participation in basic gymnastics skills requires that upper and lower limbs are alternating bases of support and locomotion. This occurs while the mid-body provides high levels of control and stability. Gymnastics-based performance actions require “core body” training which is unique to this sport. In investigations of the function of the rectus abdominus muscle according to gender and across sports, female gymnasts had higher flexion torque and higher neuromuscular efficiency values than female non-gymnasts (57). Gymnastics training can provide a complete, balanced mid-body and “postural” muscle conditioning.

**Development of flexibility**

The skill related flexibility demands of gymnastics are probably the most significant and unique aspects that serve to separate gymnastics from other sports (8, 48, 65).

A high level of flexibility can be an effective aid to the reduction of injury, preventing persons from forcing a limb to an injurious range of motion (42, 43). Gymnastics can provide this superior level of flexibility (40). But flexibility can also be overdone when a gymnast relies on an increased range of motion in inappropriate positions, particularly the lower spine and shoulder joints (9, 68).

**Enhancing both static and dynamic balance**

Gymnastics has entire events devoted to both static and dynamic balance - the balance beam for women and the pommel horse and still rings for men. Gymnasts learn to effectively balance on their feet and their hands through the ubiquitous use of handstands and myriads of balance skills on all apparatus. A recent literature review (34) compared the balance ability of athletes from different
sports. Based on the available data from cross-sectional studies, gymnasts tended to have the best balance ability, followed by soccer players, swimmers, active control subjects and then basketball players.

Interestingly, gymnasts, more so than non-gymnasts and other athletes, tend to develop a higher tolerance for imbalance or disturbances to their everyday balance (19, 20, 39, 77). Of importance is that gymnasts, more so than non-gymnasts, use less attention in correcting postural sway in their everyday life (30, 78).

_Gymnastics offers important bone forming and bone strengthening advantages._

There is now considerable evidence that participating in gymnastics can have significant and long-term osteogenic (bone forming-strengthening) advantages for boys, girls and young women over their less active peers and athletes in most other activities or sports (4, 6, 13, 23, 41, 45, 56, 61, 72, 73, 76, 79, 81).

These significant long-term osteogenic benefits are due to the non-muscular loading through impact activities and the gymnastics specific muscular loading on skeletal tissue (23).

While competitive gymnastics participation has been shown to be beneficial in bone forming and strengthening, recent investigations into non-competitive (recreational) gymnastics participation have produced similar findings that highlight the longevity of the benefits of gymnastics participation. Laing et al (2005) studied children’s bone mineral accrual before and after recreational (non-competitive) gymnastics participation. Gymnasts’ bone mineral characteristics are generally not known before starting their sport. Sixty-five pre-pubertal females who enrolled in beginning artistic gymnastics had lower bone mineral than controls (n = 78). However, after two years of recreational gymnastics participation the gymnasts experienced significantly greater accrual of forearm bone area and lumbar spine bone mineral density than the non-participating controls. It was concluded that females participating in recreational gymnastics during childhood have enhanced bone mineral gains at the total body, lumbar spine, and forearm.
Uusi-Rasi et al (2006) examined the influence of long-term non-competitive gymnastics on the maintenance of bone rigidity and physical performance. One hundred and seven retired recreational gymnasts and 110 non-gymnast controls participated in this 6-year prospective study. During the six year study both groups’ agility and leg extensor power decreased by over 3% and 10%, respectively but the original between-group differences, favouring the gymnasts, persisted. Proximal femur bone mineral content (BMC) decreased approximately 0.5% per year in both groups, and femoral neck section modulus decreased. In spite of similar rates of decline in bone characteristics and physical performance, the non-competitive gymnasts' overall physical condition was comparable to the level that their less active referents had shown approximately 5 years earlier. Importantly, several studies have now suggested that in spite of a cessation of training for up to 14 years retired female gymnasts retained an elevated bone mass into adulthood, (25, 56, 81).

Psycho-social benefits

*Academic performance*

There is some evidence to suggest that school students who are physically active perform better academically (2). However, the mechanisms by which physical education, sport, and gymnastics in particular might contribute to cognitive and academic developments are not fully understood. There is, however, some persuasive evidence to suggest that physical activity can improve children’s concentration and arousal, which might indirectly benefit academic performance (2).

It has been appreciated for some time that physical activity is connected to physiological aspects of cognitive functioning (38, 63, 70). Gymnastics participation, as well other active sport-dance activities, plays an important role here. Both human and animal studies suggest that learning complex movements stimulate the part of the brain used in problem solving and learning (63).

Podulka-Coe et al (2006) investigated the effect of overall physical activity on academic achievement. This link between activity and academic performance was most significant when kids
met USA 2010 guidelines for vigorous activity of 20 minutes a day, at least three days a week. Interestingly, grades were not affected among children who were moderately active for 30 minutes at least five days a week. Generally, physical activity can also increase academic performance indirectly by improving emotional health, self-esteem, and alertness—all of which are related to improved academic performance (75).

While it may seem obvious that performing gymnastic skills uses cognitive abilities, specific relationships between participation in gymnastics and enhanced cognitive variables are only now being considered. Barret (2000) suggests a direct positive relationship between the type of motor learning experienced through gymnastics and the enhanced reading and numeracy skills of primary school children. He describes his applied research in Florida schools where children participated in gymnastic “motor-learning labs”. The initial and follow-up research involved kindergarten and first grade classes that trained in the SMILE (Sensory Motor Intensive Learning Environment) Lab twice weekly for 12 weeks. In the two years the SMILE Lab had been operating, numerous positive results showed a direct correlation between gymnastics related movement activities and enhanced reading scores.

A recent paper (46) investigated the relationship between cognitive variables (spatial ability, reasoning, numerical ability, inductive reasoning, and reasoning and verbal comprehension) and physical prowess in sport. Results showed elite gymnasts (n = 40) present higher cognitive abilities (spatial reasoning) than other sportspeople (n= 400).

**Gymnastics enhances Task Mastery orientations**

Decades of sports based research reviewed in Ntoumanis & Biddle (1999) have shown that skill mastery (task oriented) sport programs and "task-based" motivational climates are keys to high participation rates and long-term engagement in junior sport. When many other sport activities are innately competitive and ego-oriented (through a “win-lose” of a race or game) gymnastics can be more task-oriented based around the performance of skills. Children’s participation in gymnastics
stresses task-mastery and can be a perfect medium for encouraging persistent motivated behaviours in physical education and sports.

Studies on interventions in sports motivational climate (55) show that when task-mastery orientations rather than ego oriented structures are emphasised, athletes are more likely to use subjective criteria to judge their competence, to exert more effort, to persist longer, to attribute their performance to effort, and to be more intrinsically motivated. The investigations of Lattimore (2000) and Halliburton & Weiss (2002) with female gymnasts confirm the importance of the task mastery orientations in gymnastics especially with younger gymnasts.

*Learning team-work, learning goal setting and developing the ability to focus*

Gymnastics shares with other sport the opportunity to learn about teamwork, sportsmanship, fair play, dedication, and so forth. Many would suggest that gymnastics is an individual participant sport and, superficially, it is. Because of the great challenge of learning gymnastics skills, much intra-team encouragement is demanded and the best of teamwork can be developed (21).

Goal setting involves a set of skills that are critical to performance success in gymnastics and other aspects of life. Because gymnastics has so many and varied skills to master, gymnastic participation is a wonderful laboratory for children to learn and practice goal setting.

Due to the complex skill performances, gymnastics demands and develops a high level of on-task focus. The “moment-to-moment” need to physically generate the skill performance cannot be diluted. Finishing a gymnastics skill performance is an “either-or” experience battling against the effects of gravity-space-time. While lapses in task focus in many other sports can result in simple & inconsequential “hit or miss” performance, lapses in gymnastics performance give immediate highly meaningful feedback as “gravity-space-time” cannot be ignored. Gymnasts quickly learn that it is necessary and, over time, more enjoyable to be in the “here and now” and fully focused on task. This ability to focus with laser-like power is a very advantageous life skill that all participants in gymnastics can learn.
Discussion

Overall, participation in gymnastics must be recommended as a positive foundational activity for school-aged children. Studied benefits of participation in gymnastics are: enhanced development of most of the fundamental motor patterns, enhanced flexibility, enhanced general strength and postural control, enhanced balance, enhanced anaerobic endurance, unique long-term bone forming and strengthening advantages, potential for enhanced cognitive benefits, enhanced Task Mastery orientations, potential for enhanced skill goal setting, and the ability to focus on tasks. Even so, benefits of participation should be assessed alongside the inherent risks of participation.

Risks of gymnastics participation – recent findings

Gymnastics has been perceived as a more dangerous (or more injurious) activity than other popular youth sports. While this perception has been supported in the USA university and high school settings (11, 50, 67) this is not the case in club-level gymnastics in Australia. In a recent review (22), gymnastics was found to present lower hospital emergency department presentations and hospital admission injury numbers, injury rates, and types of injuries than those found in other popular Australian youth sports. Moreover, in a review of injury rate literature the potential average range of injury rate (per 1000 hours of participation) in club-level gymnastics was found to be 0.87 - 4.43, which is well below injury rates for other popular Australian sports. While the common injuries of strains and fractures predominate in all sports, face, eye, intracranial, internal organ, spine and nervous system injuries that are common in other popular Australian sports were limited in gymnastics. In games based Australian sports (e.g. rugby-AFL codes, soccer, netball, basketball and cricket), performance is in an “open” and unpredictable environment with “moving”, colliding opponents and equipment. Contact with equipment and contact with another player accounts for the majority, and variety, of injuries in such sports. Because of gymnastics stable “field of play” and closed skill type the most common gymnastic hazards (i.e. falls) can be anticipated and controlled.
In summary, participation in Australian club gymnastics could be considered less dangerous (injurious) than other popular Australian youth sports (22).

A further criticism of gymnastics participation has been that early and intensive gymnastics training (18 hrs+ per week) may inhibit healthy growth (74). However, in investigating whether gymnastics training does inhibit growth, a literature review (10) found that heavily trained female gymnasts (20+ hours per week) may experience attenuated growth during their years of training followed by catch-up growth during the months following retirement. The same review also found that a cause-effect relation between gymnastics training and inadequate growth in females has not been demonstrated. Recent findings (31) show that in elite female AG (training hours at 30+ per week) final adult height falls shorter than genetically determined target height, though this slight impairment of growth remains well within the normal limits. This prospective study considered the 12 year period (1997-2009) growth and development data from 215 female RG and 113 female AG. Gymnasts were National team members from 28 countries who represented all continents and all races. The findings show that in both elite female RG and AG, genetic predisposition to final height was not disrupted and remained the main force of growth.

Peripubertal artistic gymnasts display elevated areal bone mineral density at various bone sites despite delayed menarche and a high frequency of menstrual disorders (49). Greater spinal bone mineral content, bone mineral density as well as trabecular volumetric density and bone strength in the peripheral skeleton has been found in former gymnasts without a history of menstrual dysfunction but not in those who reported either primary or secondary amenorrhoea. A history of amenorrhoea may have compromised some of the skeletal benefits associated with high-impact gymnastics training, but caused no difference in bone health when compared to healthy controls (24). Also, increases in bone mineral density and improvement in bone geometry associated with an increase in bone remodelling seem to be independent of osteoprotegerin (protein that plays a central role in regulating bone mass) system in peripubertal girls (48).
Conclusion

As in many things, it is the case of moderated gymnastic participation (under 20 hours per week) where the higher level and greatest number of benefits for children are realized. In such contexts, it would appear that package of benefits offered by gymnastics participation enriches and physically educates the lives of its participants in ways that are difficult to achieve through most other activities and sports (68).

References


