

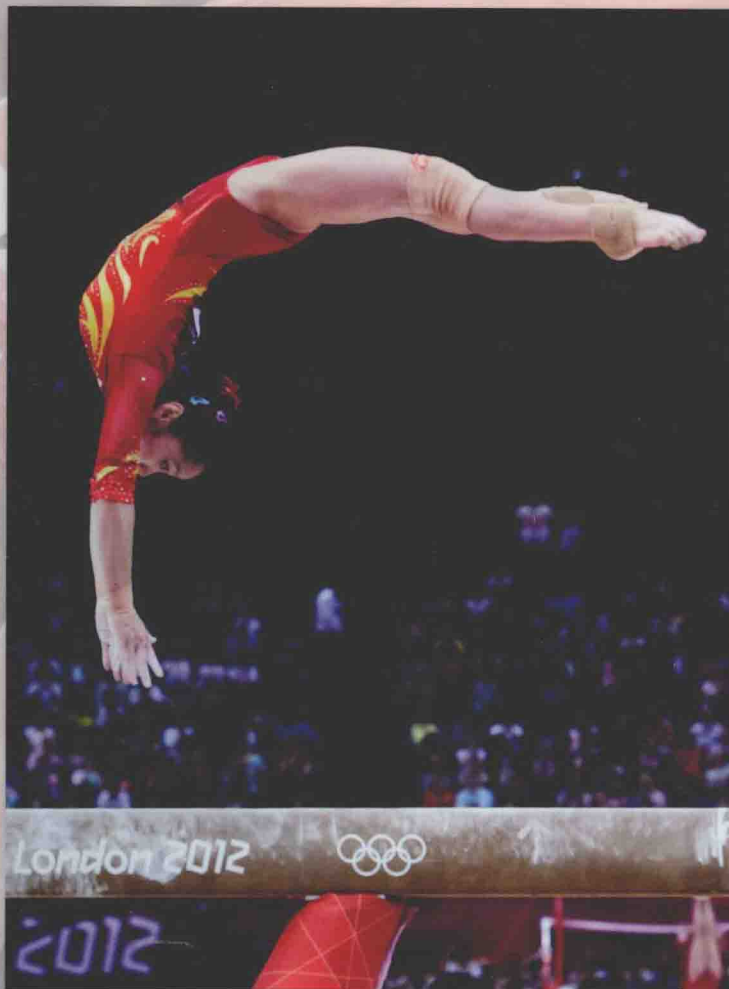
Handbook of
Sports Medicine
and Science

Gymnastics



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An IOC
Medical Commission
Publication



EDITED BY
**Dennis J. Caine, Keith Russell
and Liesbeth Lim**

WILEY-BLACKWELL



Handbook of Sports Medicine and Science **Gymnastics**

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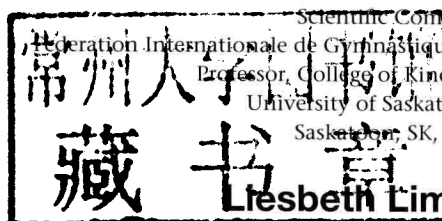
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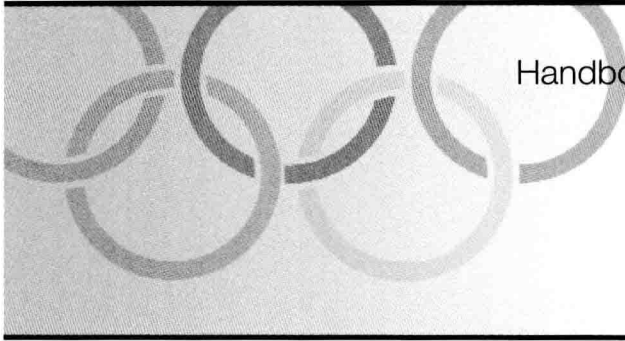
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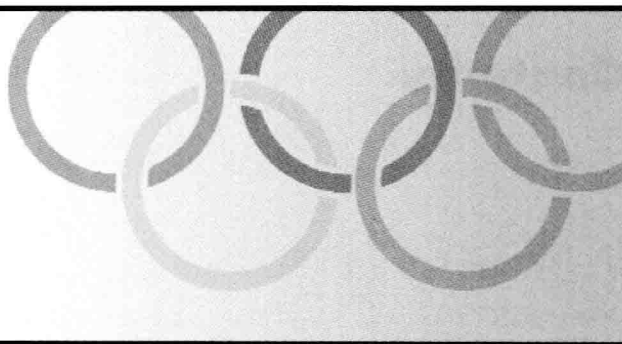
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Handbook of Sports Medicine and Science

Gymnastics

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Foreword by Dr Jacques Rogge



The various events of gymnastics have been important features of the Olympic Summer Games ever since the birth of the modern Olympic Movement at the 1896 Summer Games in Athens. The *Fédération Internationale de Gymnastique* (FIG) has been the governing body of competitive gymnastics since its foundation in 1881 and it is universally recognized as the oldest international sports organisation. Therefore, it is entirely appropriate that gymnastics is being added to the "Handbooks of Sports Medicine and Science" series published by the IOC Medical Commission.

The co-editors, Prof. Dennis Caine (USA), Prof. Keith Russell (Canada), and Dr Liesbeth Lim (The Netherlands), have developed a comprehensive outline and assembled a group of contributing authors who possess impressive credentials as regards experience, expertise, and authority, while working with athletes competing in gymnastics.

A wealth of information is presented by international authorities on the biological considerations of growth and maturation of the athletes. Extensive consideration is given to the issues of endocrinology, skeletal health, body mass management, and nutritional and energy needs. The biomechanical factors involved in injury and their roles as risk factors are emphasized. The final section includes the epidemiology of gymnastic injury, injury prevention, and the treatment and rehabilitation of injuries for the extremities, spine, trunk, and head. The comprehensive coverage is highly commendable.

We welcome this splendid addition to the Handbooks of Sports Medicine and Science series.



Jacques Rogge
IOC President

Foreword by Professor Bruno Grandi



Since the day I first stepped through the door of a gymnastics hall, I have intimately followed the evolution of the discipline from an educational and athletic standpoint. Some 60 years have afforded me an opportunity to familiarize myself with every area of the discipline—as a gymnast, coach, and judge—before ultimately occupying its highest administrative and political positions.

Well do I understand the emotion and sense of awe that permeate competitions, and I continue to be so inspired today. But that is just a small part of my interest in gymnastics. My loyalties have long been with the educational side of the discipline, and it is a joy for me to see this book published.

Today, more than ever before, people suffer from a lack of well-being that is noticeable at every level of society, particularly in the most developed countries. May this publication pave the way to finding solutions that our specialists can then pass on to the population. Growth, development, training, nutrition, and prevention: all issues are dealt with

in this book, which at the same time reports on a certain state of affairs and brings field-specific knowledge to the cutting edge.

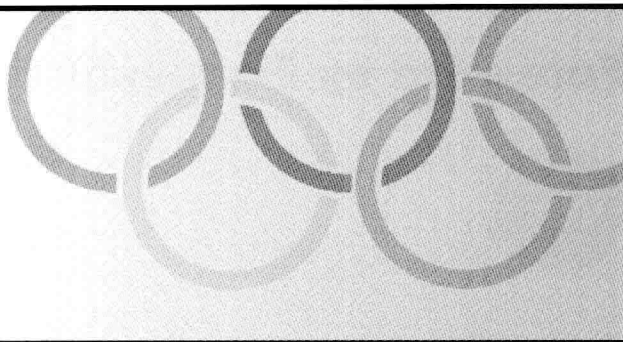
On behalf of the entire international gymnastics community, the FIG authorities, and our many gymnasts, I would like to extend my gratitude and compliments to the authors. Their contribution to the study and research of sustainable solutions is inestimable, for the greatest aspiration of any individual is his psychological and physical well-being.

With my compliments,



Prof. Bruno Grandi, President
Fédération Internationale de Gymnastique

Preface



The Olympic sports of Artistic Gymnastics, Rhythmic Gymnastics, and Trampoline Gymnastics are very popular worldwide as evidenced by the extensive media attention surrounding the Olympics every 4 years. Gymnastics is a sport that is well known for its intense training regimen and, particularly among female gymnasts, the relatively young age of its participants. Extraordinary levels of athleticism and biomechanical loading during training and competition are characteristic of these sports. Participation in gymnastics is encouraging because physical activity clearly provides many health-related benefits to those who participate. However, increased involvement and difficulty of skills practiced at an early age, with the intense training required, exposes gymnasts to high performance demands and risk of injury. Our hope is to provide the reader with useful information to assist in the management and minimization of the risks associated with participation in gymnastics, and information that also optimizes the health and competitive performance of gymnasts.

The Handbook of Sports Medicine is an ongoing series of specialist reference volumes sponsored by the International Olympic Committee (IOC) and designed specifically for the use of professionals working directly with competitive athletes. The target groups for whom this handbook is written includes (1) interested medical doctors who have little or no training in sports medicine, as well as sports medicine professionals; (2) physiotherapists and other health-related professionals; (3) team

coaches who have academic preparation in the basic sciences; and (4) knowledgeable gymnasts. The purpose of this volume is to present a comprehensive, state-of-the-art description of the medical and scientific aspects of Olympic gymnastics sports.

Part 1 of the book provides an introduction and information related to the evolution of gymnastics. Part 2 focuses on the growth and development aspects of gymnasts and includes chapters on growth and development, endocrinology, skeletal health of gymnasts, and energy needs and body weight management for gymnasts. Part 3 includes several chapters dealing with the training and performance aspects of gymnasts including gymnastics-specific biomechanics, physiology, and psychology. Finally, Part 4 deals with the sports medicine aspects of gymnastics. Chapters in this section include injury epidemiology, treatment and rehabilitation of common upper extremity injuries, treatment and rehabilitation of common lower extremity injuries, treatment and rehabilitation of common spine/trunk/head injuries, and a chapter on injury prevention.

From the outset, the editors worked to develop a plan for the book and uniformity across chapters. In November 2011, the co-editors met in Boston with Dr Howard Knuttgen, Harvard Medical School and Coordinator for Scientific Publications for the IOC, to develop an outline for the book and an approach that was consistent with other volumes

in the IOC Handbook series. Each chapter in the book follows the same major sections:

- Introduction
- Review of the literature (using topic headings specific to the chapter subject)
- Further research
- Summary
- References
- Recommended reading

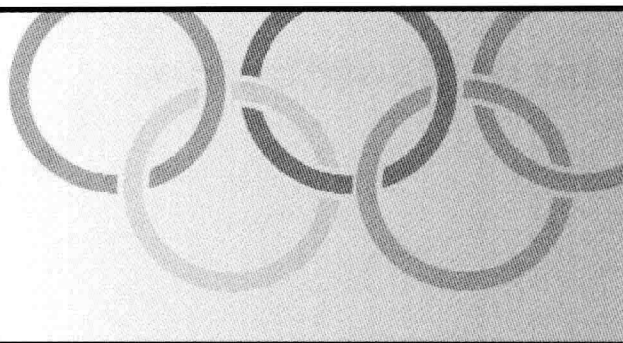
The number of references in each chapter is purposely limited given that the intent of each chapter, as far as possible, is to focus on generally accepted principles and more recent publications, yet including highly regarded older publications.

In closing, we wish to thank the authors for working diligently to provide up-to-date

chapters, and to develop text consistent in format across the various chapters. We would also like to thank Dr Howard Knuttgen for his enthusiastic support and guidance throughout this project, as well as the Medical and Scientific Department of the IOC and the International Gymnastics Federation (FIG) for their enthusiastic support. Finally, we wish to thank the production and editorial team at Wiley-Blackwell for their helpful assistance and collaboration throughout this project.

Dennis J. Caine, PhD
 Keith Russell, PhD
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 2013

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PART 1

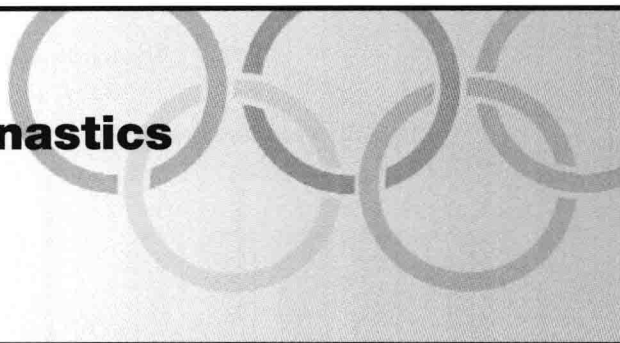
INTRODUCTION

Chapter 1

The evolution of gymnastics

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For most readers, the name “gymnastics” brings to mind those Olympic sports that gain wide media attention every 4 years. These include Men’s Artistic Gymnastics (with its six apparatuses: floor exercise, pommel horse, rings, vault, parallel bars, and horizontal bar); Women’s Artistic Gymnastics (with its four apparatuses: asymmetric bars, balance beam, vault, and floor exercise); Rhythmic Gymnastics with its lithe, flexible female gymnasts doing incredible manipulative skills with hand apparatus; and, of course, the acrobatically spectacular sport of Trampoline Gymnastics (TG). Collectively, these sports represent a very small percentage of the total gymnastics community. There are, in addition, several non-Olympic sports including Aerobic Gymnastics and Acrobatic Gymnastics plus a large family of recreational, educational, and exhibition forms of gymnastics that are grouped under the moniker Gymnastics for All. The word “gymnastics” comes to us from the ancient Greek verb “gymnazo” meaning to train naked, which is how young men in the 7th to 3rd centuries BC practiced the physical health and fitness part of their education in the outdoor “gymnasion,” supervised by the trainers or “gymnastēs.” The aristocratic young men devoted considerable time to practicing various athletic endeavors to be contested at religious festivals. They also received education in music, letters, and philosophy.

The word “gymnastics” is today an umbrella term, much the same as “aquatics,” in that it encompasses not only a group of competitive sports but also many less formalized gymnastics activities in the fields of education, recreation, and fitness (Figure 1.1). These noncompetitive forms of gymnastics are showcased every year in gym festivals in many countries, some with over 100,000 participants. There is also the World Gymnaestrada held every fourth year with 20,000 participants. The Fédération Internationale de Gymnastique (FIG) is the world’s oldest international sport governing body (incorporated in 1881 as the Fédération Européenne de Gymnastique) and has a contemporary stable of sports that includes the four Olympic sports plus two non-Olympic multicategory sports of Acrobatic Gymnastics and Aerobic Gymnastics. In addition, there are three competitive subdisciplines of TG that are not contested in the Olympic Games but are included in all other TG competitions: Tumbling, Double Mini-Trampoline, and Synchronized Trampoline.

Gymnastics-type movement was performed in the ancient Chinese, Mesopotamian, Indian, and Mediterranean cultures, which all left ample records of the importance they placed on this type of physical exercise and body movement. It was the Greeks of the Homeric and Classical eras, however, who had the most lasting influence on subsequent educational and medical gymnastics practice. Their emphasis on mind/body integration in the education of their youth would greatly influence educators 18 centuries later. Plato, whose original name

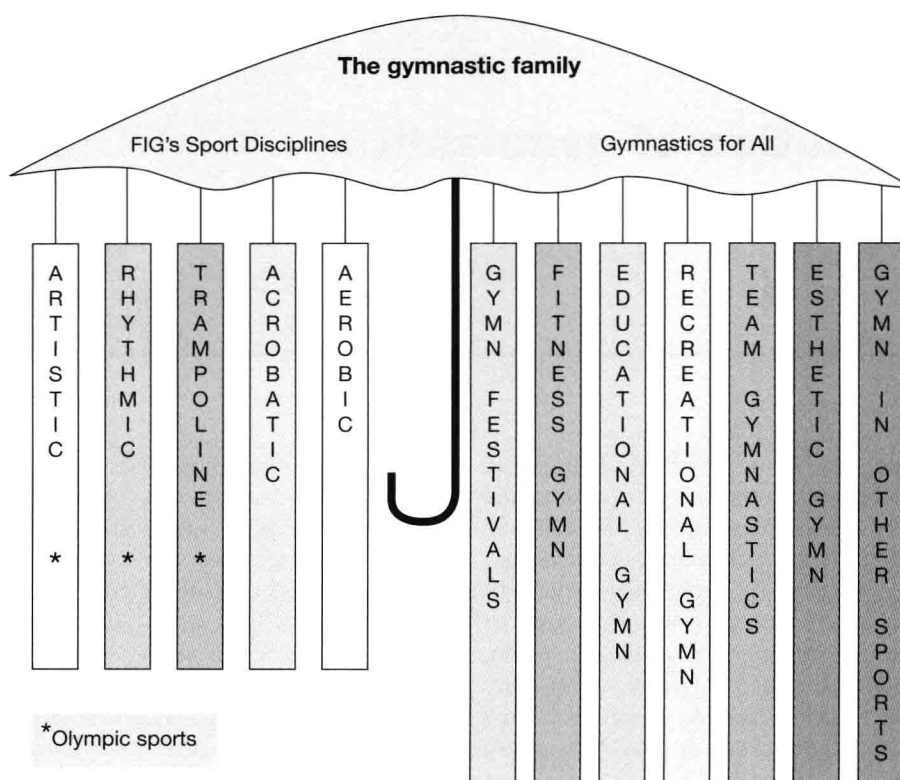


Figure 1.1 The many faces of “gymnastics.” (With courtesy of Keith Russell.)

was believed to be Aristocles, was given the name Plato by his “gymnastai” Ariston of Argos because he had a broad (platon) and athletic chest (Yian-nakis and Yiannakis, 1998).

The Romans followed the Greeks and continued many of their practices, but with more military emphasis. After the classical Greek era, the ensuing 10 centuries (the Middle Ages) had very little emphasis on sport, games, or the practice of integrating the mind and the body in education as extolled by the Greeks. It was not until the 1400s that we see a shift in thinking and a rebirth of the educational concepts introduced many centuries before by the Greeks. Let us trace how the contemporary sports and activities of gymnastics have coalesced via a fascinating and long journey through four primary ancestries: (1) the performing arts, (2) military training, (3) the medical professions, and (4) the education professions.

Gymnastics evolution from the performing arts

The earliest pictorial references to gymnastics activities come from paintings and engravings at several Egyptian sites. Most of them depict female performers tumbling and balancing and are dated from 2300 to 1000 BC (Touney, 1984). The tombs at Beni-Hassen show tumbling and ball passing and juggling skills that are surprisingly comparable to the contemporary sports of Tumbling and Rhythmic Gymnastics (Figure 1.2).

Around the same time, the Minoans, another great Mediterranean society centered on Crete, left many pictorial examples of performers vaulting and performing acrobatics on large adult bulls. Both male and female acrobats are illustrated and they appear to be paid professional performers (Gardiner, 1930). It would appear that subsequent

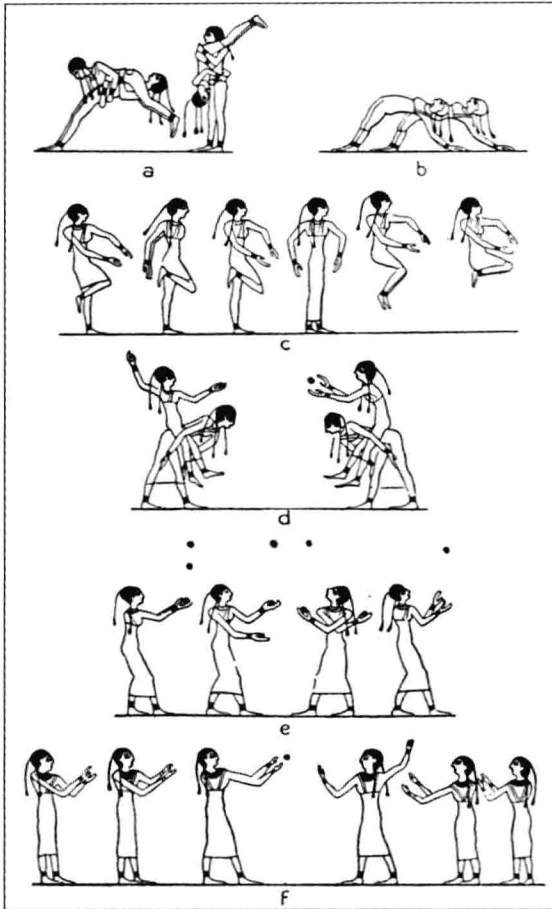


Figure 1.2 Ancient Egyptian gymnasts from tombs at Beni-Hassen (Source: Gardiner, E., *Athletics in the Ancient World* (1990) with permission from Oxford University Press.)

societies on mainland Greece took much of their reverence of athleticism and physical fitness from the Minoans and it became an integral part of Greek education. The Homeric poems describe Corfu artists combining acrobatics and dance with ball and musical accompaniment (Frantzopoulou *et al.*, 2011).

When we follow acrobatic performances through history, there is a clear thread of continuity running through them. The performances were often combined with dance and musical accompaniment, and are depicted in illustrations and text in both Western and Eastern civilizations. Chinese stone carvings from 1000 BC as well as 3rd century BC writing described acrobatic performances. By the

1st century BC, a combination of dance, acrobatics, and music called Juedixi was very popular in China. The circuses, traveling minstrel shows, and court performers throughout the world contained acrobatic performers and they often used a variety of devices to extend the acrobats' time in the air. The ancient Minoans used the momentum from grasping a bull's horns while being tossed in the air, while the Inuit of northern Canada used skins stretched between several throwers to toss one member high in the air to better see distant animals and also to entertain during celebratory events. The tossing of one acrobat by one or more others has a long tradition that continues in today's Acrobatic Gymnastics. Many aerial enhancement devices like teeterboards, Russian swings, trapezes, and contemporary devices like Double Mini-Trampoline and Trampoline have a clear genesis in the performing arts, and circuses had such devices that allowed performers to be propelled into the air. American inventor and performer George Nissen used his springing invention in a three-person traveling "rebound tumbling" act called the Three Leonardos soon after designing and building it in 1934. It was while traveling in Mexico that he learned that the Spanish word for diving board was trampoline. It is obvious that the sports of Trampoline, Tumbling, Acrobatic Gymnastics, and Rhythmic Gymnastics can trace part of their lineage directly to the various performing arts that have evolved over the millennia.

Gymnastics evolution from military training

There was an obvious appreciation for physical prowess in most ancient societies as a requisite for survival. The ancient Greek city-states developed a strong competition ethos that resulted in intercity competitions in many endeavors including physical activities like running, throwing, wrestling, and calisthenics. Many of these activities were associated with military prowess and are wonderfully described in Homer's epic poems the *Iliad* and the *Odyssey*. The Greek city-state competitions and regional athletic competitions evolved into large gatherings that culminated in four major games, one of which was

the games at Olympia first documented in 776 BC. There was great debate in Greek literature about the value of so much time being devoted to training for these festivals, especially when the athletes became increasingly more professional and the rewards for winning multiplied (Manning, 1917).

The subsequent Roman Empire took these fitness arts to even greater sophistication but directed the training to military applications instead of purely athletic contests at religious festivals. One of the most influential medical writers in history was Claudius Galenus (Galen of Pergamon, 129–200 AD) who studied in the best medical schools in the Mediterranean region. He began his medical career treating the gladiators in his home city and was responsible for greatly reducing fatalities. Through this military medical exposure he learned much about training, rehabilitation, and the knowledge that physical fitness (gymnastics) was a natural and necessary part of life. Through his large body of publications he educated the entire world thereafter on Hippocratic theory and the practice of medicine (Machline, 2004).

It was not long after, that we see the first documentation on the use of wooden horses for military training. The first written description was a 375 AD description by Vegetius of a Roman legion training on them (Kaimakamis *et al.*, 2007). In the 6th and 7th century Europe, military skills on the wooden horse were considered one of the seven knightly virtues, and there are many references to such military training. Soldiers practiced mounting, dismounting, vaulting over, and weapon use while mounted on wooden practice horses. The practice moved from military venues to fencing academies to universities, and we see it today in the sport of Equestrian Vaulting as well as pommel horse, and vaulting in both Men's and Women's Artistic Gymnastics.

A similar military influence is apparent with “Indian” clubs. There are ancient Persian and Indian depictions of stone and wooden clubs being swung as part of physical training. The British soldiers in colonial India were very impressed with the physical robustness of practitioners of “Indian” club (jori) swinging. The British army incorporated this exercise into their training, combining it with Swedish gymnastics. The first book to appear in Europe describing Indian club exercises was Donald Walker's 1834 *British Manly Exercises*. This

was followed a year later by another book *Exercises for Ladies Calculated to Preserve and Improve Beauty* in which Walker described the use of smaller, two pound Indian clubs he called “sceptres,” which are the precursors of contemporary clubs in Rhythmic Gymnastics (Todd, 2010). Indian club swinging subsequently became an important part of physical education training in many countries.

Other examples of military antecedents to contemporary gymnastics sports are the obstacle courses on which soldiers trained. The balancing and locomotory activities on horizontal logs and beams, the strength demands of rope climbing, the trapeze swinging, and the pole vaulting across ditches all led to future sport events. These types of activities, together with massed group calisthenics, were regular parts of military training, and they evolved, via inter-academy competitions, into several of today's gymnastics apparatuses and competitive disciplines.

The 10 centuries following the Roman era (5th to 15th centuries) saw a decrease in intellectual and athletic pursuits that had been so prevalent during the Greek and Roman eras. There was, however, continual development of the military arts in which physical fitness and prowess were highly valued. During this time, the training of soldiers continued to employ and develop gymnastics-type skills and many military physical training instructors subsequently became the physical education teachers and sport masters in the public and private schools of Europe, thus establishing a prominent place for gymnastics in school physical education.

Gymnastics evolution from the medical professions

It is from the medical professions that we see the earliest writings on gymnastics. The word “gymnastics” was synonymous with purposeful exercise and could refer to running, physical preparation in general, or for wrestling and boxing. There were increasing references to “medical gymnastics” such as by Herodikos of Selymbria in the 5th century BC, and Galen's *De Sanitate Tuenda* in 1st century AD. Galen advocated the importance of exercise in the cultivation of both the mind and the