Jump training in sports medicine

Entrenamiento de salto en medicina deportiva

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doi: 10.18176/archmeddeporte.00010

Through evolution, several animal species, including humans, have evolved the ability to jump. Indeed, jumping actions are common for mammals, reptiles, and insects, among others. For humans, jumping allow them to perform a wide range of activities, from dancing to moon exploration. From a sports medicine perspective, jumps have been used by athletes as a training method in preparation for competitions at least in the last 3,000 years[1].

Jump training exercises

Jump training exercises (JTE) involves multi-joint drills and large muscle groups (e.g., quadriceps). Depending on the type of jump, these may involve a stretch-shortening cycle (SSC), with a considerable voluntary effort (i.e. near maximal or maximal) during the concentric portion of the jump (i.e. against the force of gravity). In addition, some jumps may also involve considerable eccentric forces upon landing, as high as 12 times body mass[2]. In this sense, highly trained athletes use some JTE most commonly, such as bounce drop jumps from relatively high drop heights (e.g. plyometrics). However, JTE can be adapted safely and effectively for older adults, children with cerebral palsy and Down syndrome, injured athletes, among other populations[3]. Adaptation strategies may involve the performance of the concentric-only portion of the jump, assistive devices (e.g., suspension training), submaximal jumps, among other. In this sense, jump training may involve a wide range of JTE, selected according to the participant's characteristics and goals, usually incorporated in a multi-component training programme (e.g., neuromuscular training), considering a long-term physical development approach.

Mechanisms of adaptation

Responses to JTE have been studied at least from the late 19th century[4]. Although concentric-only JTE may be used to induce significant responses such as increased electromyographic activation (EMG), traditional JTE involves a rapid stretch of the muscle during the eccentric portion of the SSC, stimulating the stretch reflex. The stretch reflex implicates the activation of muscle proprioceptors (e.g., muscle spindle), which might facilitate the activation of muscle fibres during the concentric portion of the jump, thus greater EMG. In addition, muscle-tendon elastic components may have a role in the storing-releasing energy process during the SSC. Further, aside from muscle-spinal responses, supraspinal mechanisms contributing to the SSC are also involved during JTE[5]. Such acute responses to JTE accumulated over time may lead to significant adaptations[6], including increased motor unit firing rate, intra-muscular coordination, inter-muscular coordination, muscle fibre hypertrophy, optimization of muscle fibres pennation angle and muscle-tendon stiffness, bone mass increase, among others. In addition, significant responses and adaptations are also achievable through JTE for biomechanical-related variables (e.g. dynamic knee control, landing impact amortization).

Physical fitness adaptations

Considering the above-mentioned physiological and biomechanical adaptations, is not surprising to observe improvements in several physical fitness outcomes after JTE programmes. In the scientific literature improvements have been reported, including muscle power, jumping (e.g. vertical, horizontal), linear sprinting (i.e. from 5-m up to 200-m), agility and change-of-direction sprint (CODs), repeated sprinting ability with and without COD, short-term endurance (e.g., up to 60-s), long-term endurance (e.g., Yo-Yo test; 3-km running time trial), reduced contact times while running, better running economy, maximal strength (e.g., dynamic; isometric), dynamic and static balance, sport-specific performance (e.g. soccer ball kicking speed), range of motion, coordination, among others[3,7].

Jump training in sports

Among youth sports, for both male and female, from pre-pubertal (e.g., <8 years old) to post-pubertal age, JTE have demonstrated be-

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neficial effects (e.g., physical fitness; physiological and biomechanical outcomes) on athletes from different sports. Such sports includes soccer, basketball, handball, volleyball, tennis, hockey, sprinters, combat sports, and artistic gymnasts, among others. The beneficial effects derived from JTE have been reported usually without adverse effects. Further, compared to adults, youth seems to experience reduced symptoms of exercise-induced muscle damage and a faster recovery after JTE[8]. Among adult athletes, for both male and female, JTE programmes have demonstrated beneficial effects on athletes from different sports, including those previously mentioned for youth athletes, in addition to swimmers, water polo, endurance runners, ice hockey, rugby, golf, netball, among others.

Jump training for health

Although commonly associated to athletes and sport competition, JTE also have demonstrated significant favourable effects on several health-related outcomes. Such improvements includes glucose metabolism markers (e.g. fasting glycaemia and insulin), fat mass reduction, skeletal muscle hypertrophy, and acute hypotensive effect. In participants with cerebral palsy and Down syndrome, improvements have been noted in neuromuscular control and body composition. During prolonged bed rest, adapted JTE preserved muscle mass and muscle power. In older adults, adapted JTE allow improvements in balance, rate of force development, maximal strength, muscle power and EMG. In addition, adapted JTE may reduce injury risk[9], through reduction in factors associated to injury, such as reduced knee abduction-adduction, improved balance, better neuromuscular control (e.g. landing technique), and reduced strength asymmetries between knee extensors/flexors. Moreover, in case of injury, JTE can be adapted and incorporated during rehabilitation programmes (e.g. neuromuscular training). Further, the incorporation of JTE in athlete's regular training schedules may reduce their injury recurrence.

Factors associated with JTE effectivity

Participant's characteristics (e.g., JTE technique proficiency; type of sport; training age; biological maturity; sex; participant nutritional/supplementation habits) are relevant factors for JTE prescription, particularly considering the inter-individual variability to JTE programmes. In addition, an adequate prescription of JTE should consider the total duration of the training programme (e.g., weeks), total volume (e.g., number of jump repetitions; foot contacts), and volume progression rate (e.g., weekly), in addition to taper strategies. Moreover, intensity and intensity markers such as reactive strength index, jump height, movement velocity, force-velocity profile, rating of perceived exertion, among other potential markers, should be considered during JTE prescription. Further, the type of JTE (e.g., bilateral; unilateral; vertical; horizontal; loaded; unloaded; combined), the JTE order randomization between training sessions, the specificity of JTE, sequencing (i.e., before vs after regular sport practice), and external load (e.g., heavy vs. light) should be also considered. Furthermore, the type of surface (e.g., wood; grass), recovery duration (e.g., inter-session; inter-JTE; inter-set; inter-repetition) and type of recovery (e.g., cluster set vs traditional set; active vs passive) may also affect the outcomes of a JTE programme. Additionally, the combination of JTE with other training methods, such as heavy resistance training (e.g., complex training) may be effective, potentially due to post-activation potentiation or post-activation performance enhancement mechanisms, with the advantage of combining training methods in a relatively short time period.

Potential advantages over other training methods

Although several training approaches are used to improve physical fitness and health outcomes, JTE seems to be equally (or even more) effective compared to other training methods (e.g., traditional resistance training) for the improvement of several outcomes[3,7]. In addition, the implementation of JTE may be inexpensive compared to other resistance training methods, requiring little or no equipment, usually involving drills with the body weight used as resistance. Additionally, JTE may be conducted in a relatively small physical space, which may be an important advantage during certain scenarios (e.g. encountering pandemic restrictions) where athletes may be forced to train at their homes[10]. Moreover, JTE may be considered more fun compared to other training methods (e.g., flexibility, endurance), particularly among younger athletes[11]. Further, JTE may reduce the risk of injury[12]. However, rather than an independent entity, JTE should be a component of an integrated approach to training, which targets multiple physical fitness and health attributes and aligns with the goals of long-term physical development strategies.

Research gaps and future research areas

Although JTE have been used by athletes at least in the last 3,000 years, the scientific literature regarding the acute effects of JTE seems to have emerge more recently (i.e., late 19th century)[4], and the study of the adaptations to JTE programmes even more recently (i.e. middle of the 20th century)[13]. Indeed, there seems to be a paucity of scientific literature related to the factors associated with JTE dose-response relationship[3,7]. In addition, it is relatively common among published articles related to JTE to include small sample sizes (i.e. ~10 participants per group), incomplete description of JTE, and lack of control and/or group randomization, among other methodological shortcomings. In this scenario, further efforts are needed to solve important gaps in knowledge related to JTE, particularly those related to dose-response relationship in different populations, involving long-term programmes (e.g., >12 weeks) and/or multi-component interventions, and associated mechanisms of adaptations.

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