Review Article

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Plane vs Incline Plyometrics: A Review

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Abstract

Inclined plyomertics are performed at anteriorly inclined surface which pre-positions the ankle in dorsiflexion before eccentric phase. Plyometrics performed at various surface like clay, sand, wood, grass, and water training can lead to improvements in vertical jump performance, leg strength muscle power, acceleration, balance, overall agility and bone density especially in younger participants. Plyometrics performed at incline surface improve vertical jump, depth jump, counter movement jump and explosive muscle power of gastrosoleus muscle in comparison with same drills performed on various type of plane surface as muscle is at optimal length tension relation. Effectiveness of incline plyometrics on dynamic balance, speed, agility and quickness, may be a future scope of research study. Various type of drills like squat jump, depth jump, box jump at different inclination angle at different type of surfaces are still to be investigated.

Key words: Incline plyometrics; Balance; Squat jump, Depth jump.

Introduction

Fred Wilt, in (1975) a former US Olympic long-distance runner, coined the term plyometrics.[1] Plyometrics or "plyos" for short, are exercises designed to produce fast and powerful movements. They are used by athletes to better their performance in sports, especially those that involve speed, quickness, explosive power and agility.[2]

Fatouros *et al* (200) report plyometrics exercises as those that are characterized by a rapid deceleration of the body followed almost immediately by a rapid acceleration of the body in the opposite direction.[3] It is this eccentric/concentric contraction pattern which is reported to evoke the elastic properties of the muscle fibres and connective tissue in a way that allows the muscle to store more elastic energy during the deceleration phase and release it during the acceleration period.[3,4,5]

Physiology of plyometrics

The physiological adaptations expressed as changes in muscle fibre composition, associated with goal oriented plyometrics training programs, are reportedly generated through a neuromuscular response referred to as the Stretch-Shortening-Cycle (SSC).[3,4,5,6,7,8,9] The SSC involves the combination of eccentric/concentric muscle action, and is characterized by a rapid eccentric muscle action, followed by an immediate and forceful concentric contraction.[3,6,10] The concept of this rate of change in muscle action lies in the premise that when the muscle is stretched while active a greater force capability is created in the subsequent concentric contraction than what would be created from a static, non-pre stretched position.[10] Moore and Schilling suggest that the generation of force production may be linked to the series elastic components of the muscle, and increased neuromuscular reflex activity.[6] The muscle containing 'series elastic' components (Tendons, Sheath, Sarcolema) can be stretched, and on recoiling after stretching,

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can exert a volume of stored potential energy created and held within the increased number of actin-myosin cross-bridge formations held throughout the eccentrically contracted muscle. It is this mechanical actin-myosin disruption during eccentric muscle contraction, and the onwards reciprocal detachment that produces increases in muscular force, and favourable structural adaptations in muscle tissue.[6]

Shilling and Moore further suggest that as the rate of muscle lengthening increases through increased eccentric loading, a brief storage of extra elastic energy takes place, which can be used during the concentric contraction of the jump increasing mechanical force and power.[6] Fatouros *et al* (2000) found in their research on plyometrics exercise training and vertical jumping performance that part of the positive work (expressed as the force exerted across a distance) created by the stored elastic energy derives from the recoil of the tense elastic elements of the contractile proteins.[3] They further suggest that the increase in efficacy of plyometrics movements and the SSC is due to the fact that the previous muscle stretching decreases the time in which positive work is done during the next shortening.[3] It is this rapid deceleration phase of the eccentric contraction which leads to larger force production, as it is this movement which eccentrically lengthens the muscle.[5] The large amount of potential energy within the stretched muscle that is used to reach peak vertical jump velocity and jump height, and thus an increased ability to generate lateral, change of direction, and explosive movement. It is reported however, that this energy can be lost as heat (expressed as an increase in intramuscular temperature) if the concentric contraction phase of the movement is not initiated immediately.[6] This is a core aspect of effective initiation and execution of the SSC, as it is only effective in increasing force and power output if the movement activating it is produced immediately. This highlights the function of the decreased amortization or coupling time between eccentric and concentric movement.[6] GTOs have a inhibitory role during muscle contraction. GTOs are stimulated to send impulses to spinal cord that relay facilitation to limit muscle force production. It's believed that during plyometrics, GTOs excitatory threshold level is elevated so that more stimulation is necessary to produce a response from GTO, allowing for increased tolerance for additional stretch.[3,4,5,6]

Benefits of plyometrics

According to the American Council on Exercise, research studies have shown that plyometrics training can lead to improvements in vertical jump performance, leg strength muscle power, acceleration, balance, overall agility and bone density especially in younger participants.[11,12,13,14,15,16,17]

Plyometrics can improve dynamic balance-an unrealized benefit

Plyometrics training is an well accepted technique for improving the athletic performance but may also facilitate beneficial adaptations in the sensory motor system that enhance dynamic restraint mechanisms [18,19] and correct faulty jumping or cutting mechanics. Balance and stretching-shortening exercise both have a preliminary requirement of preparatory and reactive muscle activity through feed-forward and feedback motor control system. Continuous use of the stretch reflex pathways can decrease the response time and develop preparatory reactive strategies to unexpected joint loads.[18,19,20] Feed-forward strategies employ muscle preactivation to "stress shield" for articular and capsuloligamentous[21] structures and are organized based on previous experience with sport-specific activities.[22] Functional training techniques with repetitive jumping and deceleration activities may create plastic neurologic adaptations to motor programs that improve coordination for both performance and dynamic restraint. The feedback motor control process encompasses a number of reflexive pathways that continuously modify muscle activity to accommodate unanticipated events.[18,19] Because the lower extremity is subjected to high joint loads and velocities during plyometrics activities, these exercises are ideal for encouraging the reflexive pathways of feedback motor control. Reflex-mediated muscle activity is crucial element in dynamic stability and should complement pre-programmed muscle activity to achieve a functionally stable joint. Stretch-shortening exercises are a necessary component for condition the neuromuscular apparatus to respond more quickly and forcefully, permitting eccentric deceleration then developing explosive concentric contractions.[23] Wilk *et al* suggested that muscular performance gains after plyometrics training are attributed to these neural adaptations, rather than to morphologic changes.[24] For this reason, plyometrics training may enhance neuromuscular function and prevent joint injuries by increasing dynamic stability.[25]

Inclined vs plane plyometrics-established and hypothetical advantages

Established advantages

Concept of plyometrics on inclined surface was given by Kannas *et al*, 2011.[26] Incline plyometrics performed at 15^0 inclined plane is helpful in improving explosive plantar flexion and jumping performance in comparison with plane plyometrics with same drills protocol.[26,27] As triceps surae are at optimal length tension relationship[25,28] and additional elongation of dorsiflexion result in a greater energy return from the tendon.[29]

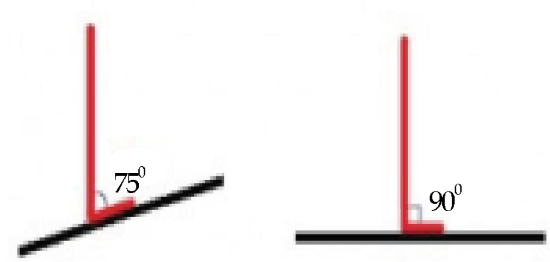
The Acute Response, Kannas *et al* (2011) reported a 10% increase in hopping height when performing the exercise on an inclined surface 15^0.[26]

The Training Response, groups of 10 athletes (all young males but no training history given) performing plyometrics drills on an incline 15^0 or flat surface. Athletes performed 8 sets of 10 consecutive jumps on 4 days a week and for 4 weeks. The incline group was observed to have significant improvements in fast depth jump performance (17% from a 20 cm drop, 14% from 40 cm) with EMG showing increased gastrocnemius activity during the propulsion phase.[27] The incline group showed a tendency for increases in squat, countermovement and slow depth jump performances, these were not significant. Fast depth jumps were described by $<50^0$ of knee flexion, slow depth jumps by $>60^0$ of flexion.

Incline plyometrics has shown better increase in medial gastrosoleus muscle activity [26,27] thus a better eccentric control on abnormal loading.

Hypothesised advantage of inclined plyometrics

- Hypothetically anteriorly incline surface keeps ankle in dorsiflexion and thus in various types of jumping activity less squatting is needed to elicit a stretch shortening cycle for same energy storage, and less lowering of centre of gravity which will allow higher vertical height in concentric phase with same energy stores.
- Muscle activity of ankle plantar flexors is about 35% of total explosive force production in vertical jumping, and to achieve it is squatting is important in order to stretch gastrosoleus muscles, but in this position gastrocnemeus is isolated as being a two joint muscle and primarily Soleus is stretched, which in turn will store less potential energy, incline surfaces may help to stretch these muscles simultaneously for explosive power output in concentric phase of vertical leaps.



- Floor inclination alters kinetic and/or kinematic variables during static standing.[30] When a person is standing on inclined plane body weight tend to produce a posterior ground reaction forces which is equal to = sin β × body weight, (β is angle of inclination of slope) which tend to create a posterior drag on line of gravity of human body. Incline surface thus challenges human body balance much extent in comparison with plane surface. Ankle appears to be the main adapting joint when walking up inclined surfaces creating a roll-over shape that would change in orientation with different levels of inclination.[31] So it is very much clear that ankle proprioceptors will be stimulated for better balance and postural control on inclined surface.

Inclined vs plane plyometrics-established and hypothetical disadvantages

Established side effect of plyometrics is delayed onset muscle soreness (DOMS), which will not be uncommon with inclined plyometrics .The soreness is felt most strongly 24 to 72 hours after the exercise caused by eccentric muscle action.[32] After such exercise, the muscle adapts rapidly to prevent muscle damage, and thereby soreness, if the exercise is repeated.[32,33] Moreover appropriate physical screening, dosimetry modification ,and gradual progression can avoid any type of side effects.[1] Any other side effect of inclined plyometrics is still to be investigated.

Future scope of research in inclined plyometrics

A lot of researches have made a strong foundation that plyometrics can improve explosive strength, speed and agility. Few researchers examined effect of these drills on different type of surfaces like grass, sand, wood and underwater.[11,12] However affect of inclined plyometrics drills on these variables are not examined till yet. There are only a handful of researches which assessed the effects of plyometrics on balance in different sports with clinically insignificant outcomes.[7,11,12,15,34] All the researchers conducted their research on plane surface which was less challenging for overall proprioception and balance mechanism and most of the researches were less biased to ankle dominating plyometrics protocol which are possibly important cause of clinically insignificant results because ankle joint is important for proprioception and postural awareness which often diminishes with various functional ankle instabilities and injury.[35] There is a dearth of research evidence to investigate the effectiveness of incline plyometrics on dynamic balance, speed, agility and quickness, which may be future scope of study. Various type of drills like squat jump, depth jump, box jump at different inclination angle at different type of surfaces are still to be investigated.

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