Decreasing landing forces: effect of instruction

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Abstract

Objective—To examine the effects of instructions related to joint kinematics, auditory stimuli, and imagery on lowering the vertical ground reaction forces associated with landing from a jump.

Study Design—Randomised controlled trial.

Setting—A laboratory in an educational institution.

Subjects—Eighty asymptomatic subjects (27 men) with a mean age of 24 years.

Intervention—Subjects were randomly assigned to the following groups: (1) instruction (limb position instructions); (2) auditory cue (listen to impact sounds); (3) imagery (metaphorical); (4) control. Subjects were required to jump from a box 300 mm in height and land on a force plate. Measures of the ground reaction force were recorded before and after the intervention.

Main Outcome Measure—The peak vertical ground reaction force recorded at footstrike.

Results—The peak vertical ground reaction forces in the technical instruction and auditory groups were significantly less than those of the control group. There was no significant difference between the auditory and technical instruction groups. There was no significant difference between the imagery and control groups.

Conclusions—When an aim of a rehabilitation programme is to minimise forces on the lower limb during landing type activities, the findings support the use of instructions related to kinematics as well as instructions that draw the patient’s attention to the sound at impact.

Keywords: landing; jumping; ground reaction forces; joint; kinematics

Numerous activities in sport and work environments require a landing from a jump to be performed. The ground reaction forces acting on the body during landing have been implicated in injury to the lower limb. It is apparent that the movement of lower limb joints can influence the magnitude of these impact forces. Studies examining the kinematics of landings from jumps have shown that subjects who land on the balls of their feet and flex their ankles and knees have lower ground reaction forces. In this respect, Magill commented that further decreases in force may be seen if the subject’s attention was drawn to salient cues in the environment—for example, the sound as the feet impact with the landing surface. In this respect, Magill suggested that subjects require a detectable reference point in the environment to be able to determine immediately the success of their performance. Magill also suggested that the performer may not always be aware of the relation between these reference points and performance success. Hence, one purpose of this study was to examine whether subjects can be taught to decrease their landing forces by drawing their attention to cues, such as the sound associated with landing.

Prapavessis and McNair also commented that the use of imagery associated with the intended movement may be effective in improving landing performance. Traditionally, it has been widely acknowledged that imagery rehearsal has the potential to play an important role in the learning and performing of a motor skill. The literature on the effectiveness of imagery rehearsal, however, has been equivocal—that is, imagery rehearsal has been found to be effective in learning and performing motor skills only in some instances and under some conditions. Evidence that not all motor skills benefit equally from imagery rehearsal comes from a meta-analysis under-
They found that the size of the imagery effect was larger for predominantly cognitive (symbolic) tasks such as finger maze learning. Landing from a jump in a stable and balanced position is a goal directed skill in which muscle activity must be generated to coordinate three major lower limb joints. Therefore it was considered to be a skill that has a strong cognitive (symbolic) component and potentially high imagery value. Thus another purpose of this study was to examine whether subjects improve their landing performance through imagery rehearsal.

In summary, given the paucity of information on the acquisition of techniques that could decrease landing forces, the purpose of this study was to examine whether different sets of instruction could assist subjects to land with lower impact forces. These instructions were concerned with lower limb kinematics, an external cue (sound), and imagery rehearsal.

Methods

Subjects

The sample consisted of 80 subjects (27 men and 53 women) whose mean (SD) age was 24 (7) years. All subjects were currently active in recreational activities—for example, soccer, badminton, tennis—for about one or two hours three or four times a week. No subjects were involved in sports involving jumping activities—for example, gymnastics, basketball—and none had a history of significant involvement in sports in which jumping and landing were an important element. No subjects reported any musculoskeletal or neurological conditions that precluded their participation in the study.

Procedures

The institution’s ethics committee approved all procedures. To provide baseline data, each subject jumped 8 times from a box 300 mm in height. This height was chosen to simulate that subjects would experience their first set of jumps to land as softly as possible for their next series of jumps, and thus relied solely on their own feedback systems for information on landing with minimal stress.

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(2) An auditory cue group: subjects were asked to listen to the sound of their landing and use that information to assist them to land more softly in subsequent landings.

(3) An imagery rehearsal group: these subjects were provided with a metaphoric imagery perspective. They were asked if they could picture one of the following statements: “bubbles floating down toward the ground”; “feathers floating down towards the ground”; “leaves floating down towards the ground”; “snowflakes floating down towards the ground”. If they could identify with one of these statements, they were then asked to picture that image and feel like that object when they performed their next series of jumps.

(4) A control group: subjects were asked to use the experience of their first set of jumps to land as softly as possible for their next series of jumps, and thus relied solely on their own feedback systems for information on landing with minimal stress.

Statistical Analysis

Statistical analysis was undertaken using the computer program SPSS (SPSS Inc, Chicago, Illinois, USA). An analysis of covariance procedure was used to compare the dependent variable across the different conditions (technical instruction, auditory cue, imagery rehearsal, and control groups). The covariate was the mean of the eight landings before and the eight landings after the intervention was used in the statistical analysis.
cited with children. The results may assist health and physical education policy makers in the development of their curriculum objectives for motor skills in children.

Our findings also provide evidence that instructions that were focused on an external cue—that is, sound associated with foot impact—led to a more improved landing performance. As discussed above, the sound of the impact may provide an important reference point from which the subject can assess performance. This point is relevant to the clinical setting, where patients and practitioners do not normally have access to equipment allowing the assessment of ground reaction forces.

How verbal instruction (be it technical information related to lower limb kinematics or information from a relevant external cue) works has been examined by Annett,19 20 who described an action-language-imagery model. In this model (fig 2), there are two independent encoding systems by which a learner can acquire information about a skill: motor (the production of action) and verbal (the production of language). These two systems are linked by a perceptual-processing bridge, referred to as the action-language bridge, which makes it possible for the learner to describe an action, generate an action, and act on verbal instructions.21 According to the action-language-imagery model, both sets of instruction help participants generate a symbolic representation (image) of the most pertinent information related to learning the movement. The image is then translated into a verbal code that can be recalled.

Our findings show that imagery rehearsal was not part of an effective strategy to assist individuals to land with less force. This finding may be related to the type of imagery that was presented to the subjects. Overby et al22 investigated the extent to which dance teachers and coaches engaged in imagery rehearsal. They found that respondents used kinaesthetic, visual, and metaphoric imagery to assist their dancers and athletes with learning and performing. According to the dance teachers and figure skating coaches sampled, a good metaphor would often help “crystallise” a specific
movement needed for successful execution of a skill. To date, there is no unequivocal evidence to suggest that the metaphoric imagery perspective is inferior to either the kinaesthetic or visual perspective.23 Perhaps, if the metaphoric imagery used in this study had the subject involved in the metaphoric experience—for example, “imagine a parachute opens up just as you take off from the box”—rather than imagining themselves as another object—for example a feather—a different result may have been obtained. Another reason why imagery rehearsal was not part of an effective strategy to assist subjects to land with less force may be related to individual differences in imagery ability. Although all subjects in the imagery group stated that they could relate to the metaphors presented to them, there is some evidence that a dispositional tendency to image influences imagery effectiveness.23 Finally, it may be that the metaphors used in this study should have been more related to the landing phase of the task rather than the flight phase. These issues warrant future attention.

The findings of this study also have relevance to clinical practice. For instance, in anterior cruciate ligament deficient subjects, McNair and Marshall12 noted a correlation of 0.87 between anterior tibial acceleration and vertical ground reaction forces. They suggested that lowering ground reaction forces may lead to decreased instability of the knee. Other authors4 have linked impact forces to the onset and development of osteoarthritis, and have suggested that lowering these forces may limit the progressive degeneration of joints. During rehabilitation, some injuries such as stress fractures also require the patient to modify their gait activities, for instance, by changing the surfaces on which they perform activities.25 The use of effective instructions and auditory cues would also assist the patient to lessen the stresses on their injury site.

The quadriceps and plantarflexor muscles work eccentrically to slow the upper body’s momentum at footstrike.25 If subjects are to perform the instructions related to joint movements successfully, sufficient strength and control of the quadriceps and plantarflexor muscles is essential.25 A deficiency in these factors is likely to lead to higher landing forces, particularly after repeated landings. Therefore, from a clinical perspective, when subjects are learning these landing techniques, it may be beneficial to include a training programme aimed at improving the performance capabilities of these muscles.

CONCLUSIONS
This study provides further evidence for the inclusion of instructions related to the kinematics of the knee and ankle joints when subjects are landing from a jump. The findings indicate that, within a single session, subjects can assimilate these instructions effectively to lower their vertical ground reaction forces. In addition, drawing attention to external cues such as the sound generated when landing can also lower vertical ground reaction forces.

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