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CHANGES IN STATURE DURING AND AFTER SPINAL TRACTION IN YOUNG MALE SUBJECTS

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ABSTRACT

Background: Spinal traction is a relatively popular procedure for increasing the intervertebral space by applying separating forces. The parameters of time and magnitude of the traction forces may influence the outcomes from this procedure and need to be investigated. The duration of the benefits derived from traction is unknown and needs to be determined so that physiotherapists can provide better and more effective treatments. Objective: This study analyzed the relationship between load magnitude and time during spinal traction in relation to stature variations. Traction effect duration was also analyzed. Method: Fifteen healthy male subjects (23.1 ± 5.77 years; 1.80 ± 0.17 m and 87.0 ± 9.6 kg) were assessed under three traction conditions (0, 30 and 60% of body weight, BW) of 42 minutes. Stature variation was used to determine intervertebral disc height variation. Stature was assessed every 7 minutes during traction of 42 minutes and every 5 minutes for 45 minutes after traction ceased. Results: 0 and 30% BW traction produced similar gains (6.09 ± 1.89 mm, 5.70 ± 1.88 mm, respectively; $p>0.05$), while these were smaller ($p<0.05$) than at 60% BW (7.01 ± 1.98 mm). Significant differences ($p<0.05$) between 60% BW and the other conditions occurred only after the 21st minute. Stature loss after traction showed that the traction effects were transient and lasted for approximately one hour. This suggests that traction loads of 30% BW are insufficient to produce stature gains similar to those observed with 60% BW. Conclusion: Traction showed a short-duration transient effect. For this effect to be maintained, it must be repeated at one-hour intervals. Its use is questioned because of its transient nature.

Key words: stature, intervertebral discs, spinal traction, back pain.

RESUMO

Alterações na estatura antes e após a tração vertebral em homens jovens

Contextualização: A tração sobre a coluna vertebral é um procedimento relativamente popular para aumentar o espaço intervertebral pela aplicação de forças de separação. Os parâmetros de tempo e magnitude da força aplicada podem influenciar os resultados desse procedimento e ainda precisam ser investigados. A duração dos benefícios derivados da tração não é conhecida e precisa ser determinada para que fisioterapeutas possam prover tratamentos melhores e mais eficientes. Objetivo: Este estudo analisou a relação entre a magnitude de carga e de tempo durante a tração vertebral sobre as variações de estatura, bem como a duração deste efeito. Métodos: Quinze sujeitos saudáveis do sexo masculino (23,1 ± 5,77 anos; 1,80 ± 0,17 m e 87,0 ± 9,6 Kg) foram mensurados sob três condições (0, 30 e 60% PC) de 42 minutos. A variação de estatura foi utilizada para determinar a variação da altura dos discos intervertebrais. A estatura foi verificada a cada 7 min durante a tração de 42 min e a cada 5 min por 45 min após o término da tração. Resultados: A tração com 0 e 30% do PC produziu ganhos similares (6,09 ± 1,89mm, 5,70 ± 1,88mm, respectivamente; $p>0,05$), que foram menores ($p<0,05$) que com 60% do PC (7,01 ± 1,98 mm). Diferenças significativas ($p<0,05$) entre 60% do PC e outras condições ocorreram apenas após o 21° min. A perda de estatura após a tração demonstrou que os efeitos da tração vertebral são transientes e duram aproximadamente 1 hora. Isso sugere que a carga de tração de 30% PC não é suficiente para produzir ganhos de estatura similares aos observados com 60% PC. Conclusão: A tração demonstrou um efeito transiente e de curta duração, para esse efeito ser mantido ele deve ser repetido em intervalos de 1 hora. O uso da tração é questionado devido ao seu efeito transiente.

Palavras-chave: estatura, discos intervertebrais, tração vertebral, dores nas costas.

INTRODUCTION

Spinal traction is a procedure used for treating and alleviating the symptoms of several clinical spinal column conditions caused by reduction of the intervertebral space and overloading of other structures (e.g. facet joints and ligaments). The objective of traction is to produce a separating force over the intervertebral discs to counteract the shrinkage caused by compressive loading and restore its mechanical functioning, thereby relieving symptoms. Many studies have been performed to analyze the effects of such procedures, in which unloading of the intervertebral discs has been induced by a variety of means. These include gravitational inversion[1,2], manual traction[3], mechanical traction[4] and self-traction[5]. Some degree of success from the use of spinal traction has been suggested[6], although the benefits have not been always confirmed[7,8]. The lack of standardization in terms of application time and load magnitude constitutes a confounding factor in attempting to understand the effects of spinal unloading.

Some studies have suggested that the load magnitude should be prescribed with respect to body mass, and have indicated that loads of 10% of body weight are satisfactory for achieving vertebral separation[4,9,10]. Others have suggested much larger magnitudes, in which loads of up to 60% of body weight have been applied[2,11,12]. There is also no consensus with regard to the duration of load application: some studies have proposed durations going from 5 to 15 minutes[4,11,13,14] up to 30 minutes[15,16] as sufficient for increasing the intervertebral space. On the other hand, in some reports, traction was applied for 3 to 4 hours[17]. These studies do not indicate any clear relationship between application time and load magnitude, and this conservative treatment remains nonstandardized.

The only study that analyzed the duration of spinal traction[10] investigated the displacement of the vertebrae *in vitro* during sustained traction loading, and concluded that most of the spinal elongation lasted for approximately 30 minutes. To the authors' knowledge, there are no other studies that have observed the duration of spinal traction *in vivo*. Quantification of the time for which the benefits of traction are retained is important for determining how frequently spinal traction series should be repeated.

The aim of this study was to determine the relationship between time and load magnitude for spinal traction forces of 0% (no traction force exerted), 30% and 60% of body mass, *in vivo* using stature variations (spinal shrinkage) as a criterion. Understanding of this relationship is of fundamental importance for improving treatment protocols, so as to achieve the supposed benefits from this procedure.

METHODS

Fifteen healthy male participants (means ± standard deviations: 23.1 ± 5.77 years; 1.80 ± 0.17 m and 87.0 ± 9.6 kg) were recruited from local community via folders and flyers and signed a written informed consent form. All the experimental procedures had been approved by the Ethics Committee of the Federal University of Paraná. Participants with known back disorders or with any low back pain episodes no more than one year before the study were not included. Participants were also screened (asked questions and examined by a physician) for other problems that could influence the results from the experiment (e.g. orthopedic problems such as severe scoliosis, chronic or recurrent back pain or disc herniation). Active movement tests of lumbar flexion, extension side flexion and rotation were performed before including participants in the experiment. All subjects were able to reach full range of movement during these tests with no pain or limiting discomfort, and therefore no exclusions were implemented. The use of male participants was an attempt to reduce certain hormonal influences (fluid retention, temperature rises or increased muscle activation) that might have influenced the response to the traction protocol. Older subjects were also not included, because of possible spinal degenerative processes that are not easy to detect and have an important impact on the mechanical properties of the discs.

Experimental procedures

All participants visited the laboratory on four occasions in the same period of the day (e.g. mornings). On their first visit, they were familiarized with the experimental procedures. The familiarization session was designed to allow participants to learn the procedures and to reduce stature measurement errors (see below). In the present study, participants were deemed familiarized when the standard deviation from five consecutive measurements was less than 0.5 mm[18].

The other three visits were used for experimental purposes, in which loads of 0, 30 and 60% of body mass were continuously applied for 42 minutes. The first session (0% body mass) was used as a control section and was always the first experimental condition to be conducted, while the other experimental conditions used were randomly assigned. Subjects were not informed of the experimental conditions they were subjected to in each section. Before applying the traction loads, participants performed a moderate physical task that consisted of 30 minutes volitional walking carrying a backpack load of 10% body mass. The experimental sessions were performed 48 hours apart and the order of the traction load was randomized. The traction load was applied with the aid of a calibrated pneumatic split traction table (Saunders Lumbar HomeTrac Deluxe). Calibration of the traction table was performed by comparing values obtained from the traction table gauge with those obtained from a strain gauge cell (Kratos, model CZC500). During traction, participants were put in Fowler's position (lying down in a supine posture with the leg supported in an elevated plane), with a pair of stabilizing belts positioned over the pelvis and thorax. In this position, the hip angle was maintained at approximately 90^o during all traction procedures (Figure 1). This posture has been recommended for traction maneuvers because of the rectification produced over the lumbar curve[6]. Traction was interrupted every seven minutes to allow the investigator to quantify changes in stature (see description below), in such a way that six repeated measurements (T_7, T_{14}, T_{21}, T_{28}, T_{35} and T_{42}) were taken. An additional stature measurement was made before beginning the traction procedures (PRE). Each measurement in the stadiometer took approximately 1.5 minutes, which correspond to the time interval imposed between each traction condition. Participants were removed from the traction table using a strategy that involved rolling over their side before standing up, to reduce the loading on the spine.


[redacted]

Figure 1. A subject during the experimental procedure of spinal traction.

To assess the duration of the traction effect, participants were requested to walk around the lab in their volitional speed, for 45 minutes following the traction period. Their walking was interrupted every five minutes. Thus, a series of nine repeated measurements was obtained (R_5, R_{10}, R_{15}, R_{20}, R_{25}, R_{30}, R_{35}, R_{40} and R_{45}).

Stature variation measurements

Changes in stature were quantified using a purpose-built stadiometer, similar to the one described by Rodacki et al.[18]. This stadiometer consisted of a rigid metal frame set at right angles to a base and inclined backwards by 15° from the vertical plane. Five anatomical points were selected to determine the shape of the vertebral column: the most posterior protuberance of the head (occiput); the middle of the deepest point of the cervical lordosis curve (approximately C4); the most prominent point of the thoracic kyphosis (approximately T7); the middle of the deepest point of the lumbar lordosis curve (approximately L3); and the apex of the buttocks, approximately at the height of the middle of the sacrum. These marker points were individually constrained by postural controls (Figure 2). Each postural control consisted of an adjustable probe mounted on a horizontal beam. The horizontal beams allowed the investigator to consistently locate the height of each marker point, while the displacement of the probes toward the participant's back provided fine depth control that constrained and defined the spinal outline. It was assumed that to successfully contact all of these markers participants had adopted a consistent position for the joints of the lower limbs and the orientation of the pelvis.

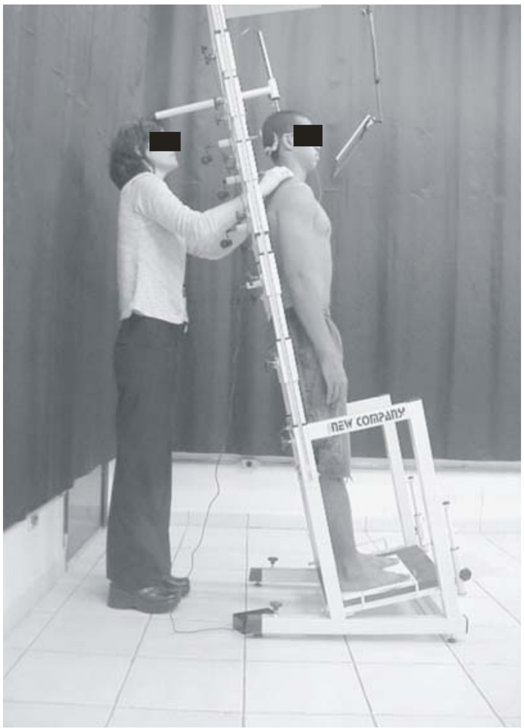
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Figure 2. Stadiometer used for stature measures. Note the location of postural controls to maintain a constant position during measurements.

During the measurements, the participants were asked to step on the stadiometer base plate and stand with their knees straight, with their body weight distributed equally between the two legs. Heels were set against a posterior beam, placed at the back of the foot support. Drawing the foot outlines allowed the feet to be positioned consistently. The participants were asked to tilt themselves backwards against the stadiometer postural controls, starting from the lowest anatomical mark and finishing with the head. They let their arms hang beside their body, with their hands at the sides of their thighs.

Undesirable head movements were controlled by two laser-emitting devices that were clamped to the left and right sides of a standard spectacle frame. When in operation, these battery-operated electronic devices emitted two tiny laser beams (class 2; wave length, 630–680 nm; maximum output, 1 mW) onto a metallic projection panel placed approximately 1 m above the participant's head, on a plane parallel to the seat base and foot support (15° to the horizontal, see Figure 2). An elastic band helped to keep the participant's spectacles in a comfortable position, with relatively constant pressure. Horizontal and vertical alignment of the head was achieved by keeping the laser beams (left and right) aligned with a pair of small marks (2.0 mm) that were fitted on two small magnets placed on the metallic surface of the projection panel. A mirror (200x200 mm), placed at a distance of 300 mm directly in front of the participant's eye level, provided visual control of the vertical laser beams. The target magnets were positioned with the participant's head and neck in normal, comfortable alignment as if looking straight ahead.

A high-resolution linear vertical displacement transducer (LVDT) was used to measure the changes in body height. The LVDT was mounted in a rigid but adjustable structure that was positioned at the top of the stadiometer in the middle of the horizontal beam and was arranged to coincide with the line of the longitudinal axis of the spine. These settings permitted the distal end of the LVDT to rest directly (by gravity) at the highest identifiable apex of the head (vertex). The LVDT was always set in such a way that the initial displacement of the rod corresponded approximately to the middle of the total displacement.

Statistical treatment

Initially, all the data were described using standard descriptive statistics. The Kolmogorov-Smirnov test was applied and confirmed data normality. Two-way ANOVA for repeated measurements was applied to analyze the stature gains during traction (PRE, T_7, T_{14}, T_{21}, T_{28}, T_{35} and T_{42}) with respect to the experimental conditions (0, 30 and 60% of body mass). A second analysis (two-way repeated measurement ANOVA) was also performed to determine the duration of spinal traction procedures during the recovery period (R_5, R_{10}, R_{15}, R_{20}, R_{25}, R_{30}, R_{35}, R_{40} and R_{45}) that were derived from the experimental conditions (0, 30 and 60% of body mass).

To analyze the stature variation rate, all individual data sets were fitted to an exponential regression equation using the quasi-Newton estimation method. An exponential model was used because many studies have described stature loss and gain as positive and negative exponential functions, respectively[19]. To analyze the stature variation rate during traction and recovery, a strategy described by Fowler et al.[20] was applied. This strategy consisted of piecewise-breakpoint statistical analysis in which a breakpoint (a deflection point) was estimated using the minimum square method. The estimation of this breakpoint allowed determination of a deflection point, from which the curve was divided into two straight lines: one anterior or equal to and the other posterior to the breakpoint. The coefficient of each segment represented the stature variation rate. The first segment (anterior or equal to the breakpoint) was likely to be related to the elastic deformation that took place in the annulus fibrosus of the intervertebral disc, while the second segment (posterior to the breakpoint) was likely to be related to the viscous response that occurred predominantly in the nucleus pulposus due to fluid loss.

The influence of traction on the mechanical behavior of the intervertebral disc during the loss and recovery periods was compared by two-way ANOVA for repeated measurements, in which segment coefficients were used as independent variables. The Scheffé test was used to determine where such differences occurred. All tests were analyzed with a significance level of $p<0.05$ using the Statistica software package, version 5.5.

RESULTS

The mean standard deviations for stature variation obtained during the familiarization session was 0.43 ± 0.06 mm after ten consecutive measurements. The small standard deviation observed during the familiarization session indicated that a brief training period was sufficient to allow participants to be measured accurately, with low error that was considered adequate. The small standard deviation found in this study was in line with other studies that reported similar results[15,18,20,21].

During the experimental sessions, no participants reported discomfort or pain relating to the mechanical traction. The mean gains in stature at the end of the traction protocols with 0%, 30% and 60% of body weight were 6.09 ± 1.89 mm, 5.70 ± 1.88 mm and 7.01 ± 1.98 mm, respectively. The traction condition of 60% showed greater gains in stature ($p<0.05$) than did the other two conditions. No significant difference in stature gain was found between 0% and 30% of body weight ($p>0.05$). Figure 2 shows the stature variation measurements during the traction protocols. It should be borne in mind that 0% refers to the experimental condition in which no traction forces were applied.

The stature variation (Figure 3) showed similar profiles under all conditions, except for the condition of 60% of body weight, which showed pronounced gains ($p<0.05$) after the 21st minute of the protocol. The rate of stature gain did not differ between the conditions until the 21st minute of traction ($p>0.05$). The greatest stature variation rate was observed after the 21st minute under the condition of 60% of body weight, and this was significantly different from what was found for the other two traction conditions ($p<0.05$). The stature variation rate did not differ significantly ($p>0.05$) between 0% and 30% of body weight.

The stature profile after traction indicated that all the participants lost stature, irrespective of their previous gains ($p<0.05$). On average, the participants shrank by 3.01 ± 1.09 mm (0% of body weight), 3.35 ± 1.35 mm (30% of body weight) and 4.56 ± 1.51 mm (60% of body weight). The largest stature loss was detected after traction of 60% of body weight ($p<0.05$), in comparison with the other experimental conditions. No significant difference in stature loss was observed between traction of 0% and 30% of body weight. It was noticed that, during the period after the procedure, the participants lost 49.0%, 58.7% and 65.0%

of the gains obtained during traction (for 0, 30 and 60%, respectively). The profile of the stature changes after traction is shown in Figure 4.

Stature loss followed a negative exponential profile under all experimental conditions. Stature loss rate was analyzed by dividing the exponential curve into two linear components.

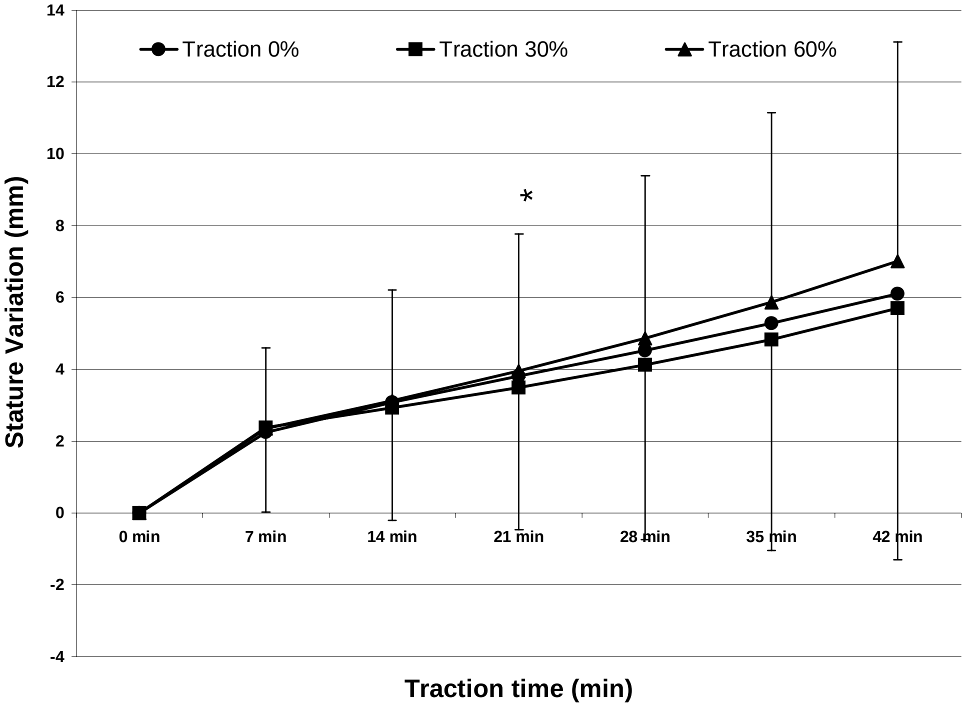

Figure 3. Stature change (mm) during the application of traction at three different loads. Note that 0 represents the baseline stature. Thin bars indicate one standard deviation above and below the conditions of 60 and 30% of body weight, respectively. The * indicates significant differences in stature gains with respect to other experimental conditions.

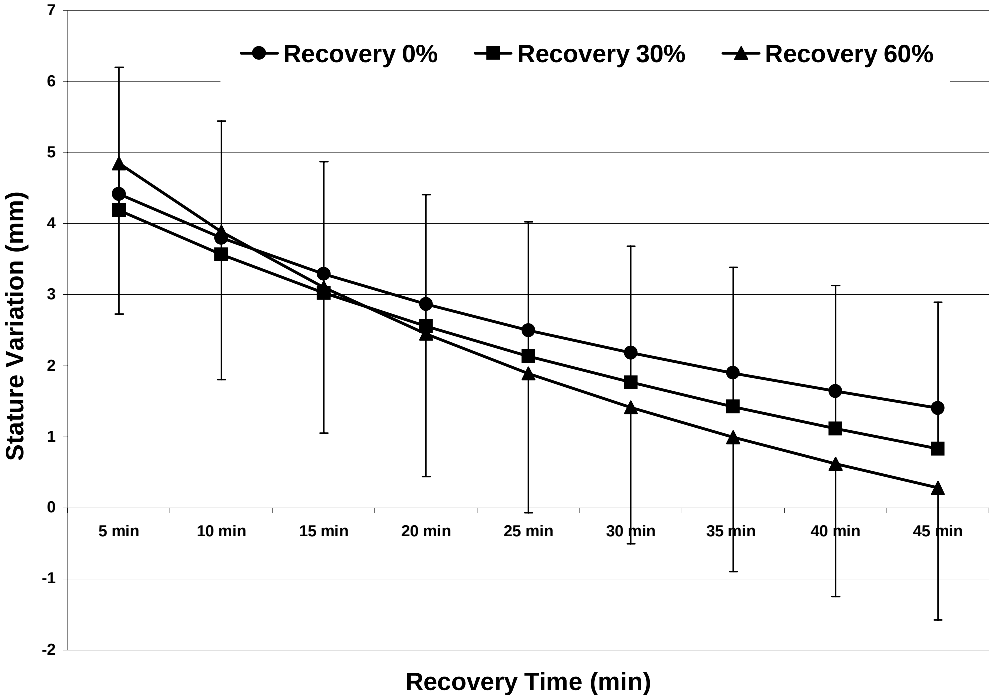

Figure 4. Stature change (mm) during recovery after the application of traction at three different loads. Note that 0 represents the baseline stature. Thin bars indicate one standard deviation above and below the conditions of 60 and 30% of body weight, respectively.

One component ($TX_{REC\ 1}$) was prior to the breakpoint, while the second component ($TX_{REC\ 2}$) was after the breakpoint. The coefficient of the linear regression equations during the recovery period showed greater stature loss ($p<0.05$) under the traction condition of 60% of body weight than for 0% and 30% of body weight. There was no significant difference in stature loss rate between the traction conditions of 0% and 30% of body weight before the breakpoint ($p>0.05$). After the breakpoint, all conditions showed similar stature loss rates and no significant differences were detected ($p>0.05$).

DISCUSSION

As traction was applied only over the lumbar area, whole body length measurements must be interpreted with caution. It is possible that other spinal regions that were not interfered with during the traction protocol may have experienced a certain degree of height variation due to the lying down and standing positions. Segmental height variations in the spine were not detectable using the methodology proposed in the present study, which is a methodological limitation of such non-invasive methods. Therefore, changes that may have occurred in the spine, other than in the lumbar area, were neglected.

Stature gain

The stature gains observed in the present study were in line with those reported by Boocock et al.[1] (5.18 mm), Leatt et al.[22] (4.18 mm) and Reilly et al.[23] (3.5 mm), who used similar stadiometers to quantify spinal length variations, following a period of gravitational inversion. However, the stature gains in the present investigation were much smaller than those found by Bridger et al.[15] (8.94 mm), who used a traction load of 30% of body weight and also quantified changes in stature by means of a stadiometer. Several factors may explain such differences. For instance, in the present study, participants got down from the traction table to move to the stadiometer six times, while in the experiment conducted by Bridger et al.[15], this was only done three times. This may have imposed a greater stress on the spines of our participants, who may not have fully benefited from traction. Therefore, greater stature gains are expected under clinical conditions in which traction is applied continuously (i.e. with no breaks for measurements).

The stature gains quantified with traction of 0% and 30% of body weight showed similar profiles throughout the traction procedure. Although stature increased during the 42 minutes of the traction protocol, such gains cannot be sustained indefinitely. Therefore, it is expected that exponential behavior would be observed over periods beyond what was used in the present study. The condition of 60% of body weight showed a profile similar to the other two experimental conditions, but only until the 21st minute. After this time, the stature gains were more pronounced than in the early stages of the protocol. These findings contrast with those reported in the study performed by Bridger et al.[15], in which the greatest stature gains were obtained within the first 15 minutes of traction with a load of one-third of body weight applied for up to 25 minutes.

Since gains in stature were still being observed at the end of the protocol, it was assumed that traction could have been carried out for a period longer than what was used in this study. It is theoretically expected that a plateau will be reached, beyond which no further gains in stature would be observed. To the authors' knowledge, no studies have imposed traction procedures that produced "maximal" stature gains, i.e. such that no further stature gains would be observed, thereby clearly reaching a plateau. The effects of prolonged traction procedures are not well known, although Le Blanc et al.[24] have demonstrated gains of up to 70 mm in space flights, in response to the absence of gravitational forces. A number of adverse symptoms (discomfort and pain) have been reported in response to such unloading[24].

The similar non-significant stature gains observed after traction of 0 and 30% of body weight are suggestive that the traction forces imposed under such conditions are not large enough to produce important changes in the intervertebral space over a relatively short period (around 1 hour). These ineffective results produced under these conditions (0% and 30% of body weight) may be caused by protective reflex mechanisms. Muscle activation may have increased the compressive stress applied on the intervertebral discs and impeded the effect of the traction forces on the spine[25]. This is in agreement with other studies that have showed that stature gains were facilitated under conditions that promoted reduced muscle activity[26]. It seems that the traction load applied under the condition of 30% of body weight may not have been large enough to overcome the muscle forces (reflex or voluntary) and the resistance of the ligaments and other forces (e.g. friction of the body on the table top), to deform the elastic elements of the intervertebral disc and produce a detectable change in the participants' stature. In fact, Krause et al.[27] have proposed that small traction forces are insufficient to cause significant vertebral separation, since such forces are dissipated by the tissues surrounding the spine. Therefore, the use of relatively light loads (e.g. 30% of body weight) must be reconsidered during clinical practice. Further studies designed to observe the use of muscle relaxing techniques applied in conjunction with traction procedures are a promising possibility for promoting fast restoration of the intervertebral space. The use of EMG data is required to confirm such speculations.

The significantly greater stature gains observed under the 60% traction condition revealed that the magnitude of the traction forces has an important effect on stature, in comparison with other experimental conditions. The similar stature gain rate found up to the 21st minute under the condition of 60% of body weight reinforces the idea of a reflex mechanism that restricts the adaptive response of the spine to the traction stimulus. After the 21st minute, it seems that participants were able to relax (i.e. they became familiarized with the stress) and let the separating load act more efficiently. EMG data are required to confirm this hypothesis. Other mechanisms may also have influenced the response of the spine under the condition of 60% of body weight. One other possible explanation for this phenomenon can be drawn from the way in which the intervertebral discs responded to the distracting stimulus. During the first instants of traction, the disc height gains could have occurred by a slow fluid influx. Ramos & Martin[16] demonstrated that negative hydrostatic pressure increases with traction load, which causes greater fluid absorption by the nucleus pulposus. Because the fluid cannot migrate very rapidly to the center of the intervertebral disc, tension is applied to the fibers of the annulus fibrosus, causing them to deform towards the center of the disc. Therefore, the first gains in intervertebral disc height may be much more related to pressure variations than elastic deformation of the annulus fibrosus and ligaments. After some fluid has been absorbed, the elastic elements of the intervertebral disc are deformed more intensively. This possibility may have acted in conjunction with the muscle reflex mechanism hypothesis and cannot be ruled out as an explanation for the greater stature gain rate obtained from the middle of the procedure, i.e. from the 21st minute under the condition of 60% of body weight.

In the present study, the rapid restoration of the intervertebral discs obtained under the condition of 60% of body weight indicated that this traction load is more indicated for participants that require rapid regain of the intervertebral space (e.g. to alleviate pain symptoms) than are lighter traction loads. Other studies have also proposed 60% of body weight as a more effective load for reducing back pain and radicular symptoms[11,14]. Further studies that analyze the effects of traction in participants with load back pain are necessary to determine whether such results apply to participants with ongoing back pain. In the light of the evidence of elevated muscle tension in patients with low back pain[26,28], it is probable that greater traction loads would be required to overcome this. This may explain the results from other studies that used small traction loads. For instance, Beurskens et al.[29] failed to demonstrate a clear benefit from spinal traction on low back pain symptoms using the overall perceived effect between sham loads (around 15% of body weight) and traction (around 42% of body weight). It may be argued that loads below 60% of body weight are not large enough to promote significant intervertebral disc gains that result in clear treatment benefits. It should be borne in mind that the results from the present study may differ from those among subjects referred for spinal traction, in whom protective muscle reflexes may influence the stature gain outcomes.

Stature loss

Most experiments involving traction have focused on how the spine responds to the magnitude and duration of load application, but none have investigated the loss after such procedures, i.e. how long the effect of traction maneuvers lasts. On the other hand, there are several studies that have demonstrated that intervertebral discs lose height following a negative exponential profile[25,30,31]. Stature loss is a consequence of the diminution of the intervertebral discs and has been used as a load parameter[19,32]. Use of the magnitude of stature change as a loading parameter is possible because the magnitude of the loss is related to the magnitude of the load, i.e. greater loads cause greater stature loss than do smaller loads[33,34].

Comparing stature loss variations between studies is difficult, because the discrepancies in duration and magnitude of the load application are not consistent. In the present study, stature loss occurred after all traction conditions. Complete return to the initial stature (pre-traction) was not observed within the recovery period (45 minutes). An estimation of the return time, using the linear equations put forward in this study, revealed that the transient effect of traction lasts no longer than 70, 60 and 50 minutes for the traction of 0, 30 and 60% of body weight, respectively. Closer inspection of the stature change profiles showed that all the changes occurring after the breakpoints (TX_{REC2}) were similar under all experimental conditions. The condition of 60% of body weight demonstrated a more pronounced loss in the period immediately following traction. Such findings are in agreement with other studies that have analyzed stature variation after loading, which revealed that greater changes happened during the first minutes of load application[21,35]. The greater rate of change may be attributed to the fast increase in the hydrostatic pressure of the disc. When the internal pressure of the disc rises, it causes radial deformation of the walls of the annulus fibrosus, which bulge the disc and reduce its height. As the fluid cannot be expelled instantly from the nucleus pulposus, the initial deformations are thought to occur to the elastic elements of the intervertebral disc, with almost no fluid loss. This mechanism is an attractive way to allow the intervertebral discs to dissipate and absorb loads repeatedly, without losing efficiency. However, when compressive loads are imposed over a long period (e.g. gravitation or carrying an object), only a small amount of fluid is gradually and slowly expelled and the intervertebral disc creeps. The findings of Botsford et al.[36] revealed insignificant elastic deformation in the intervertebral discs after prolonged periods of body weight bearing. This second mechanism may explain the slow component detected in the stature variation profile.

The relatively fast return to the initial conditions (pre-traction) brings into question the use of spinal traction as an effective procedure for increasing (restoring) the intervertebral space. In fact, the short duration of spinal traction revealed that the long period spent applying such procedures may not be effective in terms of the expected benefits, which were very transient. However, it is not known whether low back pain relief is sustained after returning to the initial condition.

CONCLUSION

Traction procedures have been used to increase the intervertebral disc height and the intervertebral space. Although the experimental procedures of this study caused changes in whole body length (stature), it has been widely accepted that such changes are intimately related to changes in spinal length, which are related to disc height. It should be borne in mind that measurements of stature variation describe general spinal behavior in response to whole spinal traction. Thus, inferences about local spinal changes (e.g. in the lumbar region) are not possible with the present methodology. Age, gender, body mass and stature are also intervening factors that require further investigation.

The present study confirmed that spinal length and thus intervertebral space height can be significantly increased by traction. This study suggests that the benefits from traction are more pronounced with loads that exceed the muscle resistance generated by protective muscle mechanisms. Thus, loads of 60% of body weight were found not only to cause the largest stature gains, but also to give rise to faster gains than were obtained with lower traction loads, beyond approximately the 21st minute of the intervention. Hence, such loads are indicated when rapid restoration of the intervertebral space is required. The results from the present study may be applied for clinical purposes, although further analysis is necessary, in order to observe whether the proposed equations are suitable for individuals who are likely to need to receive traction (e.g. patients with back disorders). Patients with ongoing back problems may require higher loads due to their greater protective muscle activation.

One of the interesting findings from the present study was that the traction only had a brief, transient effect that was dissipated within approximately one hour after its application. The long period spent applying spinal traction brings into question the use of such procedures, since the benefits were sustained for a relatively brief period. The transient nature of this effect suggests that series of traction must be repeated at intervals of approximately one hour if the intervertebral space is to be maintained, although this seems unreasonable in terms of clinical practice. Further studies involving different load duration, load magnitude and participants (i.e. symptomatic subjects) are required. It would also be interesting to consider further studies that include muscle relaxation techniques in conjunction with traction procedures to test the arguments suggested in the present study. The use of larger cohorts is also necessary.

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