We're delighted to announce that Tim Cacciatore et al are due to have a piece of research published in the journal *Gait & Posture*. In the following Tim helpfully explains its context, and its significance. He also gives his opinion, as a scientist and an AT teacher, of the risks of teachers relying on unsupported explanations of why the AT works, whilst having faith that a plausible scientific theory will eventually be established.

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GENERAL STUDIES OF THE SIT TO STAND MOVEMENT

The reason for studying the AT's effect on standing up (i.e. sit-to-stand) is, of course, that chair work is fundamental to the AT. Understanding the underlying physics and neural control will hopefully yield general insight into AT principles, such as mechanical advantage and the Head-Neck-Back relationship. While such insight could probably be gained by studying other AT procedures, the extensive research already performed on sit-to-stand will undoubtedly be advantageous in helping reveal the AT's effects on coordination.

To date, several hundred research papers have been published on sit-to-stand. The first of these was by Frank Pierce Jones, which is remarkable given both his background and the technology available in the 1960s. It wasn't until thirty years later (about 1990) that the sit-to-stand movement was actively researched and some of its basic underlying biomechanics were understood.

Sit-to-stand, like all whole-body movements, is brought about by the precise coordination of many muscles. Surprisingly, little is known about how the nervous system coordinates such extensive activity during whole-body actions. Even understanding the role of an individual muscle is daunting because it can have complex, whole-body effects. Thankfully, however, the coordination of whole-body movements can be understood in terms of three simple but fundamental mechanical problems, or constraints, that our nervous systems must solve. These constraints are: 1) keeping the body's centre of mass between foot and seat contact (i.e. to maintain balance); 2) providing antigravity support (to prevent skeletal collapse); and 3) generating the forces necessary to move.

The basic phases of the sit-to-stand movement can easily be understood in terms of these three mechanical constraints. One begins to stand up by inclining the upper body forward, which moves body mass toward the feet in order to maintain balance after lift-off (constraint 1). If you think you don't need to lean forward to stand up, move your feet forward by about 30 cm and try again. Prior to leaving the chair, hip and knee extensor muscles are activated to provide antigravity support for these joints (constraint 2). This is also commonly referred to as "weight shift". Finally, after leaving the chair, the leg and trunk joints are straightened to achieve upright stance (constraint 3). While this description may seem overly mechanical and irrelevant from an AT perspective, these basic mechanical constraints must be satisfied, even when standing up with exemplary Use. Moreover, our research described below suggests that the AT enables one to satisfy these constraints in a different way.

In addition to characterising the basic movement phases, previous non-AT studies of sit-to-stand have quantified the coordination of hip, knee and ankle movements, the effect of different chair height and foot positions, as well as coordination differences that occur from ageing and disease. A number of other studies have focused on the specifics of balance – how far forward and how fast the mass must travel in order to stand up. While many studies have measured overall forces (torques) occurring at hip, knee and ankle joints as well as the electrical firing patterns of many muscles, neither the stiffnesses in joints nor the forces exerted by individual muscles have been measured during this action, as this is technically difficult. In general, there has been an overabundance of studies examining the strength required, because some researchers think weak quadriceps muscles underlie difficulty standing up in old age. This notion is highly contentious, however. Finally, several groups have characterised spinal bending during sit-to-stand (i.e. pulling the head back, and hollowing the back). However, the cause and relevance of these spinal movements is not yet understood.

PREVIOUS STUDIES ON THE EFFECTS OF AT ON SIT-TO-STAND COORDINATION

Jones et al [1] and Stevens [2] directly examined the effects of the AT on sit-to-stand coordination. Because these papers were published long ago and are still referred to by the AT, it is pertinent for us to understand what these findings mean today, as both the knowledge base and publication standards have changed dramatically.

While Jones performed several studies on sit-to-stand, only one of these focused on the effects of the AT [1]. This study compared coordination with AT hands on guidance prior to, or throughout the movement to unguided habitual coordination. He also tested subjects before and after they had a series of lessons. His main measures of coordination were movement trajectories, obtained from film. He quantified angles of the head and neck, chest, the lowest position of the head, as well as its maximal horizontal velocity and vertical acceleration. He found that the AT affected many of these, including the head/neck and chest angles as well as reducing maximal head velocity and acceleration. In general, the largest AT effect was with full guidance, compared to adjustments only or lessons alone. However, by today's standards, interpreting the use of guidance during the movement is problematic because it is difficult to determine the confounding mechanical effect of guidance. While he later obtained a plate for measuring forces under the feet, only data from a single trial from each condition were published [3].

Chris Stevens and colleagues published a paper on sit-to-stand in 1989 [2]. The primary focus of this study was to examine how foot placement (habitual vs. standardised) affects the movement. In addition, they examined the effect of an AT teacher's hands on guidance on coordination. While changes in foot forces, muscle activity and movement were noted, the result is considered anecdotal because it was performed on a single person. In addition, because Stevens only assessed the AT's effects through hands on guidance, it is difficult to interpret the data.

From today's perspective, these studies provide evidence that the AT does change sit-to-stand, including spinal coordination, overall movement trajectory, as well as reducing maximal acceleration and velocity. Unfortunately, little else can be concluded about the AT's effect on the mechanics or neural control of this movement.

THE LACK OF AND IMPORTANCE OF THEORY IN THE AT

While the work of Jones forms an extensive body of carefully conducted, pioneering research, it fails to provide a plausible modern scientific basis for the AT. This failure does not result from the quality of the original work, but from the lack of subsequent research over the last 40 years.

Jones did formulate a theoretical framework to explain his data that was appropriate for the time. This hypothesis was that altered head-neck reflex responses caused the coordination changes he observed. Jones later referred to this proposed reflexive change as a change in "postural set", meaning a cognitive state that affects automatic behaviour. While we understand his motivation from our subjective AT experience, this cannot be concluded from the data. First, neither head-neck reflexes nor postural set was measured, thus there is no empirical support that such changes affected coordination. Today, this extent of speculation in a primary research publication is not permissible. Second, the idea that a particular head-neck relationship unleashes reflexive automatic coordination is not tenable. Magnus' head neck reflexes are known to disappear early in development, and generally speaking motor coordination is known to be much more complex.

While Jones' experimental data still stand, the importance of his emphasis on head and spinal coordination has not been generally appreciated. Because of this, his research has had little impact on the scientific literature, outside research on the AT. Jones was ahead of his time: he studied how the AT affected sit-to-stand coordination before sit-to-stand coordination was understood.

In all of science there are only two things that make a topic important: either it has a clear theoretical basis or there is very carefully controlled, compelling experimental evidence that indicates its importance. An example of the former is the current search for the Higgs particle - enormous sums are being spent on the LHC at CERN because of its theoretical importance. An example of the latter is the ATEAM trial, where a carefully controlled RCT found that the AT helps back pain. Even in the latter case, however, there is resistance to the experimental ATEAM result, because no clear theoretical basis exists for why the AT reduces pain. This reflects the tremendous emphasis in science placed on understanding why things happen - not just what happens.

Today, we continue to face the same difficulty as Jones because the principles and practice of the AT still lack a clear theoretical basis. Because it is not obvious why the measures that Jones quantified, such as the “head/neck angle” or “chest angle”, might fundamentally affect the sit-to-stand movement, it is difficult to argue convincingly for their relevance. This is also true of many phenomena in the AT, such as “pulling the head back”, “pulling the knees in" , "jumping out of the chair” and "collapsing”. As opposed to being fundamental, all these observations are considered phenomenological, which means that they can’t be derived from theory. Without additional theoretic underpinnings such measures will attract little scientific attention.

It is difficult to formulate a plausible theory for the AT because it likely lies at the border between neuroscience and mechanics, and it’s not clear exactly how much of each contributes to a given AT principle, practice or observation. On one hand, neuroscience (especially motor control) is a young field with much to be learned and relatively few established theories. Thus, the neuroscience principles necessary for understanding the AT may not be known yet. On the other hand, mechanics is a mature field where the theories (mainly based on Newton’s laws) are established, but deceptively complex. Thus while there could be a mechanical basis for a phenomenon in the AT, for example lifting the heels off the ground as one moves to sit down, its mechanical basis could be difficult to formulate.

Without a theory of the AT, it will be necessary to rely more heavily on experimental evidence for its concrete benefits to establish a wider recognition of the value of the

Technique. While performing illuminating experiments on AT benefits is not always straightforward, the challenges are soluble, and such evidence will likely continue to mount. It will be the establishment of a plausible theory for the AT, its principles and methods that will be the major challenge to scientific research ahead.

Part of the difficulty we face is that we often confuse our experiential understanding for scientific understanding. We disguise our scientific ignorance with vague but unsupported explanations of why the AT works. For instance, Jones' work is often mentioned in conjunction with two of these unsupported theoretic notions: that either postural reflexes or the startle pattern relate to the AT's mechanism. Clearly the AT changes some type of automatic postural behaviour. However, strictly speaking, a reflex is a specific type of stereotyped automatic reaction. While the AT may indeed affect such reflexes, to our knowledge no study has examined the AT's effect on them. In contrast, Jones did measure the startle pattern and noted that it resembled poor coordination [4]. However, as with reflexes, the effect of the AT on the startle pattern has not been quantified, and thus there is no experimental support that the startle pattern underlies poor Use.

While the lack of a plausible scientific theory has not prevented the AT from being taught or passed on, exaggerating our understanding of its underlying mechanism has downsides, whether we do so knowingly or not. It tarnishes our credibility and hinders our willingness to accept a more valid and explanatory theoretical framework as one emerges. Admitting we don't really know why the AT works doesn't undermine our competence to practice and teach this profound experiential body of knowledge.

RECENT STUDY ON AT SIT-TO-STAND COORDINATION

"Prolonged weight-shift and altered spinal coordination during sit-to-stand in practitioners of the Alexander Technique"

by Tim Cacciatore, Victor Gurfinkel, Fay Horak and Brian Day [5].

While the purpose of this study was to better understand how the AT affects sit-to-stand, the results begin to suggest a theoretical basis for some general AT principles, which we describe at the end.

The experiment compared sit-to-stand coordination between 15 AT teachers and 14 matched control subjects. Subjects were asked to stand up "as smoothly as possible without using momentum" five times while their movement and foot force were measured.

To assess the effects of the AT we examined several basic measures of coordination. First we quantified the duration of various phases of sit-to-stand - the time to: a) lean the trunk forwards, b) shift weight to the feet, c) transfer momentum from the upper to lower body, d) straighten the legs and rise to standing.

While the overall time to complete the movement was similar between groups, two of the phase durations were markedly different. First, AT teachers took twice as long to shift their weight onto the feet (roughly 20% of the movement vs. 10% for controls). Second, teachers spent less time transferring momentum, which suggests they used less forward upper body momentum to stand up.

In addition to taking longer, teachers' weight shift was smoother. While control subjects abruptly took weight off their feet before increasing it, AT teachers simply increased the weight smoothly (this agrees with the preliminary observations from Jones and Stevens). We think control subjects use this unloading to increase their forward momentum.

Because AT teachers' weight shift was prolonged, it lasted from the beginning of trunk inclination up until lifting off the chair. In contrast, controls shifted all their weight at a specific trunk angle, just before lift-off. This means teachers are able to solve the balance problem (i.e. shift their mass forwards toward their feet) at the same time they generate antigravity support for the legs. In contrast, control subjects stand up as two separate sequential actions - leaning forward, and then rapidly shifting weight. We think this ability to solve these two basic mechanical problems simultaneously is fundamental to chair work. Interestingly, data from a previous study suggests young children may also have this ability.

We think that controls had difficulty standing up in a single continuous action, because simultaneously bringing their mass forward and shifting weight requires that hip and knee extensor muscles lengthen while generating large forces (i.e. contract eccentrically). This means that an even stronger force must pull on the ends of these muscles, so that they lengthen and keep the body mass moving forward.

One potential source of energy for this force is the trunk. It is interesting then that the lower spinal bending we observed in AT teachers (in neck, thoracic and lumbar regions; also consistent with Jones' findings in the neck) theoretically helps to transfer mechanical energy from the trunk to the limbs. This would help lengthen knee and hip extensors and could enable teachers to stand up in one continuous action (i.e. simultaneously bring the body mass forward and shift weight).

Our recent finding that the AT changes muscle tone [6] may also be relevant to teachers' ability to stand up. The lower stiffness in teachers' hip muscles would make these easier to stretch during sit-to-stand. The greater responsiveness of neck and back muscles would help transfer mechanical energy across the spine. However, for sit-to-stand, the increased responsiveness would have to act to oppose length changes, rather than the yield, as occurred during twisting.

These results naturally suggest a hypothesis regarding Alexander's concepts of mechanical advantage and Head-Neck-Back relationship. Specifically, this hypothesis consists of several parts: 1) the essential feature of mechanical advantage is that it requires lengthening contractions in the limbs while opposing gravity; 2) this requires an efficient transfer of energy across the trunk; 3) the HNB relationship facilitates this transfer of energy; 4) responsive tone acts to 'allow' lengthening in leg extensors by yielding; 5) responsive tone acts to maintain the HNB relationship by opposing length changes in neck and trunk muscles. It is notable that the main procedures of mechanical advantage (standing up and sitting down in a chair, monkey, lunge and squats) all theoretically require lengthening contractions in leg muscles while opposing gravity. Thus, this may explain why these specific procedures are so beneficial for teaching the HNB relationship.

While this hypothesis plausibly explains our findings for sit-to-stand as well as other aspects of AT behaviour, it doesn't shed light on the complexity of the underlying muscular coordination, and it is preliminary. There is much more to the AT that it doesn't address, of course, such as what cognitive and attentional processes are involved, AT principles such as inhibition, or how these mental phenomena relate to motor coordination. However, it is a start. Many more studies are needed to understand it in detail, test it directly and determine what aspects of it are incorrect.

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