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Advantages and disadvantages of stiffness instructions when studying postural control

Cédric T. Bonnet

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Corresponding Author: Dr. Cédric T Bonnet, Ph. D.

Corresponding Author's Institution: CNRS

First Author: Cédric T Bonnet, Ph. D.

Order of Authors: Cédric T Bonnet, Ph. D.

Abstract: To study and understand the maintenance of upright stance, researchers try to discover the fundamental mechanisms and attentional resources devoted to postural control and eventually to the other tasks (e.g., counting in the head). During their studies, some researchers require the participants to stand as steady as possible and other simply ask the participants to stand naturally. Surprisingly, a clear and direct explanation of the usefulness of the steadiness requirement seems to be lacking, both in experimental and methodological discussions. Hence, the objective of the present note was to provide insights about advantages and disadvantages of this steadiness requirement in studies of postural control. The advantages are to study fundamental postural control, to eliminate useless postural variability, to control spurious body motions and to control what the participants are thinking. The disadvantages are that this requirement only leads to study postural control in unnatural upright stance, that it changes the focus of attention and the nature of postural control, that it induces a dual-task and that it eliminates or reduces the opportunity to record exploratory behaviors. When looking carefully at the four advantages of the steadiness requirement, one can believe that they are, in fact, more disadvantageous than advantageous. Overall therefore, this requirement seems illegitimate and it is proposed that researchers should not use it if they are searching to understand postural control. They should use this requirement, only if they search to know the maximum strength of their participants' postural control in their study.

Suggested Reviewers: mounir Zok

Department of Human Movement and Sport Sciences, University Institute for Movement Science,
Piazza Lauro de Bosis 6, 00194 Rome, Italy
mounir.zok@iusm.it

He studied quiet stance with and without the steadiness requirement and was concerned with methodological procedure, as in my technical note.

r.f. Reynolds

School of Sports and Exercise Sciences, College of Life and Environmental Sciences, University of
Birmingham, Edgbaston, Birmingham B15 2TT, UK
r.f.reynolds@bham.ac.uk

He studied quiet stance with/without the steadiness requirement. This is my main question also

Cédric Bonnet
Laboratoire de Sciences Cognitives et Affectives (SCA LAB)
UMR CNRS 9193
Eurasanté, Université Lille2
150, Rue du Docteur Yersin
59120 - LOOS

February 10th 2015

Dear Prof. Tim Theologis, Editor in Chief of Gait and Posture,

Please consider the attached manuscript, "Advantages and disadvantages of using the stiffness requirement to study postural control", by Cédric T. Bonnet, for publication in your journal as a Technical Note. The manuscript is original, not previously published, and not under current consideration elsewhere. As the single author, I was fully involved in the preparation of the manuscript.

Sincerely,

Cedrick T Bonnet
Ph. D. CR1 CNRS

Cédric Bonnet
Laboratoire de Sciences Cognitives et Affectives (SCA LAB)
UMR CNRS 9193
Eurasanté, Université Lille2
150, Rue du Docteur Yersin
59120 - LOOS

February 10th 2015

Dear Prof. Tim Theologis, Editor in Chief of Gait and Posture,

In the manuscript, "Advantages and disadvantages of using the stiffness requirement to study postural control", by Cédric T. Bonnet, there is no conflict of interest, as stated at the end of the manuscript.

Sincerely,

Cedrick T Bonnet
Ph. D. CR1 CNRS

**Advantages and disadvantages of using the stiffness requirement to study postural
control**

Cédric T. Bonnet¹

¹Laboratoire de Sciences Cognitives et de Sciences Affectives (SCA LAB), Université de
Lille, CNRS, Lille, France.

Corresponding author:

Cédric T. Bonnet

Tel.: +33 320 446281

Fax: +33 320 446732

e-mail: cedrick.bonnet@chru-lille.fr

Running head: stiffness requirement and postural control

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3 **Advantages and disadvantages of using the stiffness requirement to study postural**
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11 Cédric T. Bonnet¹
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14 ¹Laboratoire de Sciences Cognitives et de Sciences Affectives (SCA LAB), Université de
15
16 Lille, CNRS, Lille, France.
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18
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21

22 Corresponding author:
23

24 Cédric T. Bonnet
25

26
27
28 Tel.: +33 320 446281
29

30 Fax: +33 320 446732
31

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33 e-mail: cedrick.bonnet@chru-lille.fr
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Abstract

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49 *Keywords:* postural control; postural sway; steadiness requirement; methodology;
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51 standardization
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1. Steadiness requirement mostly required in experimental studies

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3 In upright stance, individuals oscillate continuously even they try to be completely
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5 immobile. They sway more when they stand naturally than when they try not to sway [1].
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7 Hence, there are irreducible and superimposed adjustable postural sways. In the science of
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9 postural control, the question may be asked whether researchers should ask their participants
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11 to stand naturally or as steady as possible? Very surprisingly, this question has not been
12
13 clearly discussed yet. In history, researchers performed the steadiness requirement or not
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15 without explaining their choice [2-4]. Even methodological debates to standardize the study
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17 of postural control did not discuss this steadiness requirement [5-6]. The objective of the
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19 present note was to provide insights about advantages and disadvantages of this requirement.
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2. Advantages to use the steadiness requirement

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30 Firstly, the general consensus is that the steadiness requirement allows to study the true
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32 nature of postural control because only the fundamental mechanism – irreducible sway – is
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34 analyzed. Studying the two levels of sway together could hide some significant findings if
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36 these sway do not evolve in the same manner from one condition to another, for example if
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38 irreducible sway increases whereas superimposed adjustable postural sway decreases.
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43 Secondly, the steadiness requirement allows reducing between-subjects variability in
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45 eliminating useless postural sways (idea partially evoked by [6]). Analyses with less
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47 variability can better avoid type II error, that is not finding significant findings that really
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49 exist.
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53 Thirdly, the steadiness requirement insures, by definition, that the participants do not
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55 perform voluntary body motions. Any body motion, even slight, could be confounding
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57 variable because they may spuriously affect the magnitude of postural sway.
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2 Fourthly, the steadiness requirement controls what the participants are thinking during
3 trials. Indeed, they are only thinking about performing the steadiness requirement.
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7 8 **3. Disadvantages to use the steadiness requirement** 9

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11 Firstly, standing upright as steady as possible is unnatural. Haddad et al. [7] pointed out
12 that experimental findings can be misleading when the experimental conditions are not
13 representative of everyday life. Accordingly, Bonnet et al. [8] showed that healthy, middle-
14 aged adults display impairment in postural control (the center of pressure location
15 mechanism) in natural upright stance. In contrast, there was no such impairment, even in
16 older adults, when the participants tried to sway as little as possible [9]. Overall therefore,
17 older adults exhibit natural deficiencies in postural control but can overpass these deficiencies
18 when they perform the steadiness requirement.
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31 Secondly, the steadiness requirement creates a confounding variable because participants
32 are performing a dual task and not a single task. They have to control their posture (the first
33 task) and sway as less as possible (the second task). The participants may engage more
34 cognitive resources in this seemingly single task than in any kind of dual tasks, which is
35 irrelevant. Indeed, the participants can engage a lot of effort to sway as less as possible
36 because they can always perform the task better. In contrast in dual tasks, the participants
37 only need to succeed in the task performed and they do not need to engage more cognitive
38 resources than necessary. Therefore, the supposedly greater engagement of neuromuscular
39 activity [10] or implication of higher level of brain activation [11] in quiet stance than in dual-
40 task conditions may be simply spuriously caused by the steadiness requirement.
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55 Thirdly, the steadiness requirement prompts the participants to focus their attention on
56 their own posture in the single control upright stance condition (i.e. an internal focus) while
57 they focus more their attention on the performance of the secondary task under dual-task
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1 conditions (i.e. an external focus [12]). Internal focus may lead to greater body sway because
2 of a change in the nature of postural control from a more automatic to a more voluntary
3 control with more neuromuscular activity [13]. As a consequence, the center of pressure
4 displacement is more regular, and thus less effective, when individuals think about their own
5 movement [13]. So why would researchers study postural control in worse conditions than in
6 usual life?
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14 Fourthly, the steadiness requirement may reduce (and even remove) an experiment's
15 ability to detect exploratory behavior. The exploratory role of postural control is now widely
16 acknowledged [7,14] and its occurrence in studies of postural control should not be ruled out.
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18 Body sway sometimes can have positive consequences on perception and action, which can
19 be used to more successfully interact with the environment [14]. Natural relevant behaviors
20 should not be hidden by this steadiness requirement.
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32 **4. Advantage or disadvantage to use the steadiness requirement?**

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35 In this chapter, I come back to the four advantages of the steadiness requirement to
36 discuss that they are in fact, not so advantageous.
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40 With respect to the study of the true nature of postural control, there is no reason to
41 believe that irreducible postural sway is more representative of fundamental postural control
42 than natural postural sway. Irreducible postural sway is representative of the maximum
43 strength of postural control whereas natural postural sway is representative of postural control
44 in real life. The superimposed adjusted postural sway is not merely a noisy, useless,
45 irrelevant, incorrect or to-be-limited signal emitted by the postural control system [7,15].
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55 Instead, postural sway contains deterministic components that should be studied [15].
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With respect to the variability of postural sway, it is more advantageous to avoid type II error in a condition more representative of everyday life (natural postural sway) than in a unnatural condition almost never performed in real life (irreducible postural sway). Researchers may find fewer significant results in natural conditions but this is what matters to understand postural control.

With respect to the third advantage of the steadiness requirement, it is very easy for an experimenter to see if their participants perform spurious movements not related to the trial performed (e.g., scratching the body, moving the arms, speaking...). Experimenters can eliminate or redo trials if necessary. Although the steadiness requirement definitely insures no spurious body movements, the results are definitely not biased without this requirement if experimenters are careful of what their participants do.

During trials performed without the steadiness requirement, researchers cannot control what the participants are thinking and it may indeed significantly affect postural control [11]. However, the cognitive involvement is much higher when the participants try to sway as less as possible because they constantly think about this requirement. Without this requirement, they may or may not think about something and the intensity of their thoughts would be definitely lower. Therefore it seems more problematic to use this steadiness requirement than not to use it.

In conclusion, three of the four advantages of the steadiness requirement are actually more disadvantageous than advantageous. Moreover, I discussed four main disadvantages of the steadiness requirement in chapter 3. Hence, my arguments show that this stiffness requirement should not be used in experimental studies of postural control. They also suggest that a general consensus should be discussed and decided in the future to standardize this procedure to study postural control.

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8 **Acknowledgment**

9 Nothing to declare.
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11 **Conflict of interest**

12 Nothing to declare.
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16 **References**

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Cédric Bonnet
Laboratoire de Sciences Cognitives et Affectives (SCA LAB)
UMR CNRS 9193
Eurasanté, Université Lille2
150, Rue du Docteur Yersin
59120 - LOOS

February 10th 2015

Dear Prof. Tim Theologis, Editor in Chief of Gait and Posture,

In the manuscript, "Advantages and disadvantages of using the stiffness requirement to study postural control", by Cédric T. Bonnet, here are the highlights:

- In posture studies, subjects are either asked to stand as steady as possible or not
- Very surprisingly, no (clear) discussion exists on the validity of this requirement
- This note fully analyses advantages and disadvantages of this methodological aspect
- 4 advantages and 4 disadvantages are discussed but disadvantages are clearly worse

Sincerely,

Cedrick T Bonnet
Ph. D. CR1 CNRS