IPC Athletics – Prosthesis Maximum Allowable Standing Height

Amendment to IPC Athletics Classification Rules and Regulations Appendix 1, 3.1.4.3.1 and 3.2.4.3.1

October 2015
Background & Rationale

IPC Athletics wish to provide the background and rationale for the introduction of a new method of calculation Maximum Allowable Standing Height (MASH) from 1 January 2017.

IPC Athletics current rules and regulations identify the Maximum Allowable Standing Height (MASH) on the basis of an historical formula introduced into para-athletics. The rationale for the current measures cannot be reproduced or accurately agreed by the parties involved, but as reference it is a measure on the basis of ulna length and demi-span. The estimated standing height through these formulas was then increased by 2.5%. This increase was to correct for inter-individual errors in the formula. This method is identified in this report as MASH2.5.

IPC Athletics had identified this formula to have potential errors and in order to ensure a fair and level playing field, the matter was addressed in the IPC Athletics Classification Research Project, initiated in 2006. The MASH2.5 method uses only arm measurements, and thus people with long arms relative to their stature are likely awarded an unfair advantage compared to people with short arms relative to their stature. Furthermore, the method cannot be used for athletes with amputations in upper and lower limbs, and the validity of the method has yet to be reported in the scientific literature.

Only recently, IPC Athletics retrieved a copy of a scientific publication from 1986 (Bassey, 1986, Demi-span as a measure of skeletal size, Annals of Human Biology, 3,5:499-502) that identifies demi-span as “a practical alternative measure of skeletal size”. It is believed that the MASH2.5 measure is derived from this publication. However, with its implementation in the sport an error occurred in the measurement of demi-span. The 1986 publication identifies that the measurement of demi-span “is taken only half way across the body to the sternal notch and the finger joints are excluded by locating a steel tape measure at the finger roots”. The sport implemented a formula with measure of demi-span measured “from the middle of the sternal notch to the tip of the middle finger in the coronal plane”. This led to an overestimation of standing height.

A new formula on the basis of sitting height, based on the work of Contini (1972) was proposed via the IPC Athletics Classification Research report, which was subsequently approved by IPC Athletics and the IPC Governing Board in 2009 for implementation post London 2012. This method is identified in this report as CONTINI2006.
Following the 2011 IPC Athletics World Championships in Christchurch the CONTINI2006 method was amended to an average of 3 measures: estimated standing height on the basis of sitting height, femur length and humerus length. The +2.5% addition was kept because of historical reasons. The amendments are based on:

1. Evolution of the 2006 project based on dialogue with the athletes and nations in Christchurch
2. Underestimating of standing height with sitting height as single measure of prediction
3. Ability for estimates on basis of femur and humerus length to correct for this underestimation

This revision was approved by IPC Athletics and the IPC Governing Board in 2011 taking effect post London 2012. This method is identified in this report as CONTINI2011.

Following the implementation post London, IPC Athletics received criticism from its membership because the CONTINI2011 measures significantly lowered the maximum standing height of those athletes affected. The membership argued that no due consultation had been put in place and that the operational impacts of the differences found were not duly considered by IPC Athletics. Under this pressure, IPC Athletics withdrew the CONTINI2011 measures and reinstated the MASH2.5 measures.

Following this reversal of decision IPC Athletics informed its membership that further assessment of different assessment methods would be initiated, with a final decision due mid-2014.

As a consequence of this IPC Athletics approached Prof. Wolfgang Pottharst, professor at the Deutsche Sporthochschule Köln and expert on the biomechanics of prosthetic running (co-investigator of the initial Pistorius investigation), who accepted the invitation from IPC Athletics to assist in this process.

In June 2014, Prof. Pottharst reported on the work conducted by the Deutsche Sporthochschule in collaboration with Prof. Hiroaki Hobara from the National Institute of Advanced Industrial Science and Technology in Tokyo. They reported to IPC Athletics based on a research paper from Dr. Alicia Canda (High Council for Sports, Spain)-on “Stature estimation from body segment lengths in young adults – Application to people
with physical disabilities” (Journal of Physiological Anthropology, 2009, 28(2): 71-82). This method is identified in this report as CANDA.

The results of CANDA and CONTINII2011 were presented against MASH2.5 and MASH (without 2.5% addition), with the differences remaining significant against CANDA and CONTINII2011 and MASH2.5 and MASH (without 2.5% addition). It was also noted by IPC Athletics that the CANDA report is based on results from a Caucasian population, though simulations of the findings on data from non-Caucasian athletes were undertaken.

As part of the confirmatory validation of the proposed amendments, Sean Tweedy, IPC Classification Research Centre lead at the University of Queensland a (small) multi-cultural replication study of the CANDA method in association with the IPC Athletics Classification Advisory Group on able-bodied youngsters with same age range as those in the CANDA study. These results, currently submitted for publication in a peer-review journal, confirm that different CANDA formulas have a higher criterion validity (measure of how well one variable or set of variables predicts an outcome based on information from other variables) to estimate stature, compared to both the MASH (even without 2.5% addition) and the CONTINII2011 measurement.

The recommendations were discussed with the IPC Athletics Management Team, who considered the practicalities of implementation along with forthcoming recommendations from various NPCs and committees.

As a result the decision to implement the CANDA formula with immediate effect was not realistic given the proximity of the start of the Rio 2016 Qualification period and the short-term investments required by athletes to modify the length of prostheses (and subsequent re-adjustment of running patterns).

The IPC Athletics Management Team also considered the IPC Equipment Policy (IPC Handbook, Section 2, Chapter 3.10), which applies to all sports in the Paralympic Movement. In particular the considerations on physical prowess are relevant to the actual theme (allowing progress to optimize athlete potential cannot be unrestricted in terms of technology and equipment being ‘assistive’ of nature with the ultimate performance being generated by human endeavour).

As a result from the above, IPC Athletics submitted a proposal to the IPC Governing Board which was approved in October 2014 and is outlined below:
Implementation of CANDA formula from 01 January 2017 onwards for all athletes 
with double lower limb amputation/dysmelia competing with prostheses (applicable 
to all disciplines in the sport)

- The formula that has the highest $R^2$ (explained variance) will be taken for which all 
  parameters can be measured (this is, exclusion of the estimations that include 
  measures of the lower leg). These are:
  - For male athletes with above knee amputation: formula M10m
  - For male athletes with below knee amputation: formula M8m
  - For female athletes with above knee amputation: formula M10f
  - For female athletes with below knee amputation: formula M8f
- The reported PE (pure error of measurement) is added to estimate the final 
  standing height
- In case of multiple dysmelia, the formula with the highest $R^2$ for which all 
  parameters can be measured will be used.
- In cases with complex dysmelia where no measures for the upper limb can be 
  calculated, standing height will be based on the measurement of sitting height as 
  applicable in the CONTINI2011 method (for male athletes: sitting height/0.52; for 
  female athletes: sitting height/0.533)
- In case of athletes with combined above and below knee amputation, the formula 
  for below knee amputation (M8m/f) will be taken with measurement of the thigh on 
  the non-affected side.
New Ruling

New rule 3.1.4.3.1 Determining maximum allowable standing height for athletes with bilateral low limb deficiency competing with prostheses

For ambulatory athletes running, jumping and throwing with prostheses (i.e. bilateral above knee amputations, bilateral below knee amputations, or combined above knee and below knee amputations, bilateral lower limb dysmelia), the following formulas apply for measuring the maximum allowable standing height:

• For athletes with below knee deficiencies:

<table>
<thead>
<tr>
<th>Males</th>
<th>Max. height = -5.272 + (0.998 x sitting height) + (0.855 x thigh) + (0.882 x upper arm) + (0.820 x forearm) + 1.91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>Max. height = -0.126 + (1.022 x sitting height) + (0.698 x thigh) + (0.899 x upper arm) + (0.779 x forearm) + 1.73</td>
</tr>
</tbody>
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• For athletes with above knee deficiencies:

<table>
<thead>
<tr>
<th>Males</th>
<th>Max. height = -5.857 + (1.116 x sitting height) + (1.435 x upper arm) + (1.189 x forearm) + 2.62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>Max. height = -4.102 + (0.509 x arm span) + 0.966 x sitting height) + 2.14</td>
</tr>
</tbody>
</table>

• In cases of multiple dysmelia, the formula with the highest $R^2$ for which all parameters can be measured will be taken from the Canda 2009 publication (Canda, A. (2009). Stature estimation from body segment lengths in young adults: Application to people with physical disabilities. Journal of Anthropology, 28(2):71-82). The PE score will be added to the formula in table 4 (males) or table 5 (females) of this study.

• In cases with complex dysmelia, where no measures for the upper limb can be calculated, standing height will be based on the following formula:

<table>
<thead>
<tr>
<th>Males</th>
<th>Max. height = sitting height / 0.52</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>Max. height = sitting height / 0.533</td>
</tr>
</tbody>
</table>

• In cases of athletes with combined above and below knee amputation (or comparable dysmelia), the formula for below knee deficiency (see above) will be taken with the measurement of the thigh on the non-affected side.
All measures are taken in conformity with the ISAK standardized measures (International Society for the Advancement of Kinanthropometry).