# Musculoskeletal model

## Introduction

Different human walking models have been developed in different simulations environments. Wang [1]–[3] proposed a walking musculoskeletal model developed in a three-dimensional simulation environment (ODE), composed of rigid elements and muscles. The model developed was compared initially with SIMBICON model by Yin and Colleagues [4]. The parameters of the latter model were taken from Laszlo and Colleagues [5], that were used also by Wooten and Hodgins [6] and obtained by Dempster and Gaughran [7].

Immagine che contiene treppiede

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Figure ‑: Wang's model

Table : Rigid bodies properties: Inertia, mass and com position.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rigid body | I11 [kg∙m2] | I22 [kg∙m2] | I33 [kg∙m2] | I12 [kg∙m2] | I13 [kg∙m2] | I23 [kg∙m2] | MASS [kg] | COM\_X [m] | COM\_Y [m] | COM\_Z [m] |
| trunk | 0,355667 | 0,281527 | 0,224534 | -0,00066 | 0,046738 | 0,000573 | 19,73372 | -0,02687 | 0 | 0,418811 |
| head | 0,020577 | 0,025556 | 0,016009 | 0,000103 | -0,00455 | -0,00019 | 4,340525 | 0,044758 | 0 | 0,727415 |
| larm | 0,014082 | 0,013769 | 0,003605 | -0,00011 | 0,000609 | 0,003195 | 2,07099 | -0,04751 | 0,230317 | 0,420066 |
| lforearm | 0,003846 | 0,004819 | 0,001705 | -8,40E-05 | 0,001554 | 8,40E-05 | 1,106703 | 0,01435 | 0,29966 | 0,169661 |
| lhand | 0,000294 | 0,000326 | 0,000263 | 5,41E-05 | 6,18E-05 | -3,67E-05 | 0,340742 | 0,124985 | 0,28817 | -0,01471 |
| rarm | 0,014082 | 0,013769 | 0,003605 | 0,000113 | 0,000609 | -0,00319 | 2,07099 | -0,04751 | -0,23032 | 0,420066 |
| rforearm | 0,003846 | 0,004819 | 0,001705 | 8,40E-05 | 0,001554 | -8,40E-05 | 1,106703 | 0,01435 | -0,29966 | 0,169661 |
| rhand | 0,000294 | 0,000326 | 0,000263 | -5,41E-05 | 6,18E-05 | 3,67E-05 | 0,340742 | 0,124985 | -0,28817 | -0,01471 |
| pelvis | 0,172383 | 0,128551 | 0,137961 | -0,00103 | -0,01024 | 0,003287 | 13,92486 | -0,00933 | 0 | 0,055554 |
| lthigh | 0,116352 | 0,122695 | 0,0305 | 0 | 0 | 0 | 8,082408 | -0,01689 | 0,119198 | -0,16101 |
| lshank | 0,043804 | 0,044413 | 0,004433 | 0 | 0 | 0 | 3,222323 | -0,02189 | 0,127317 | -0,58163 |
| lfoot | 0,001314 | 0,003847 | 0,003659 | 0 | 0 | 0 | 1,172905 | 0,013716 | 0,109219 | -0,87142 |
| rthigh | 0,116352 | 0,122695 | 0,0305 | 0 | 0 | 0 | 8,082408 | -0,01689 | -0,1192 | -0,16101 |
| rshank | 0,043804 | 0,044413 | 0,004433 | 0 | 0 | 0 | 3,222323 | -0,02189 | -0,12732 | -0,58163 |
| rfoot | 0,001314 | 0,003847 | 0,003659 | 0 | 0 | 0 | 1,172905 | 0,013716 | -0,10922 | -0,87142 |
| ltoe | 8,71E-05 | 0,000871 | 0,000174 | 0 | 0 | 0 | 0,188729 | 0,136157 | 0,107308 | -0,89295 |
| rtoe | 8,71E-05 | 0,000871 | 0,000174 | 0 | 0 | 0 | 0,188729 | 0,136157 | -0,10731 | -0,89295 |

Table : Relative positions between joints and link COMs by Wang..

|  |  |  |  |
| --- | --- | --- | --- |
| Relative positions between joints and link COMs | X [m] | Y [m] | Z [m] |
| neck - trunk | 0,030144 | 0 | 0,222712 |
| head - trunk | 0,041488 | 0 | 0,085892 |
| lshoulder - trunk | -0,02392 | 0,16471 | 0,079314 |
| larm - lshoulder | 0,003289 | 0,065607 | -0,07806 |
| lelbow - larm | 0,030199 | 0,052112 | -0,16104 |
| lforearm - lelbow | 0,031657 | 0,017231 | -0,08937 |
| lwrist - lforearm | 0,078953 | -0,00262 | -0,14279 |
| lhand - lwrist | 0,031682 | -0,00887 | -0,04158 |
| rshoulder - trunk | -0,02392 | -0,16471 | 0,079314 |
| rarm - rshoulder | 0,003289 | -0,06561 | -0,07806 |
| relbow - rarm | 0,030199 | -0,05211 | -0,16104 |
| rforearm - relbow | 0,031657 | -0,01723 | -0,08937 |
| rwrist - rforearm | 0,078953 | 0,002617 | -0,14279 |
| rhand - rwrist | 0,031682 | 0,008873 | -0,04158 |
| back - trunk | -0,01936 | 0 | -0,22048 |
| pelvis - back | 0,036908 | 0 | -0,14277 |
| lhip - pelvis | -0,00756 | 0,117592 | -0,03764 |
| lthigh - lhip | 0 | 0,001606 | -0,17892 |
| lknee - lthigh | -0,005 | 0,002567 | -0,23786 |
| lshank - lknee | 0 | 0,005552 | -0,18277 |
| lankle - lshank | 0 | -0,01752 | -0,23817 |
| lfoot - lankle | 0,035607 | -0,00057 | -0,05162 |
| lball - lfoot | 0,098725 | 0,000574 | -0,02034 |
| ltoe - lball | 0,023716 | -0,00248 | -0,00118 |
| rhip - pelvis | -0,00756 | -0,11759 | -0,03764 |
| rthigh - rhip | 0 | -0,00161 | -0,17892 |
| rknee - rthigh | -0,005 | -0,00257 | -0,23786 |
| rshank - rknee | 0 | -0,00555 | -0,18277 |
| rankle - rshank | 0 | 0,017524 | -0,23817 |
| rfoot - rankle | 0,035607 | 0,000574 | -0,05162 |
| rball - rfoot | 0,098725 | -0,00057 | -0,02034 |
| rtoe - rball | 0,023716 | 0,002485 | -0,00118 |

Zatsiorsky and Seluyanov collected data such as mass, length and inertia [8]. A detail review of available anthropometric data was done by Leva and Dumas [9], [10] to adjust measurement collected by earlier works by Zatsiorsky, McConville and Young. In the following, anthropometric data proposed by De Leva were considered as are the reference for human movement studies Table 1.

Table 3: anthropometric data for masculine subject by (Table 4 Leva 1996). Inertia values of hip and shoulders are included in the body of the trunk.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Segment | Mass [% of 73 Kg] | Radii of gyration sagittal (Z)[%] | Radii of gyration transverse (X) [%] | Radii of gyration longitudinal (Y)[%] | Length [m] | COM (from proximal) [%] DIRECTION X: IN LOCAL COORDINATE OF THE BODY |
| Head | 6.94 | 31.2 | 0.36.2 | 37.6 | 0.3143 | 0.5976 |
| Arm | 2.71 | 15.8 | 0.28.5 | 26.9 | 0.2817 | 0.5772 |
| Forearm | 1.62 | 12.1 | 0.27.6 | 26.5 | 0.2689 | 0.4574 |
| Hand | 0.061 | 40.1 | 0.62.8 | 51.3 | 0.0862 | 0.7900 |
| Trunk | 43.46 | 19.1 | 0.37.2 | 34.7 | 0.5319 | 0.4486 |
| Thigh | 14.16 | 14.9 | 0.32.9 | 32.9 | 0.4222 | 0.4095 |
| Shank | 4.33 | 10.3 | 0.25.5 | 24.9 | 0.434 | 0.4459 |
| Foot\* | 1.37 | 0.124 | 0.257 | 0.245 | 0.1 | 0.4415 |
| Toes \* |  |  |  |  | 0.06 |  |
| Hip |  |  |  |  | 0.3\* |  |
| Shoulders |  |  |  |  | 0.45\* |  |

\*Foot and toes values to be checked (coming from Isman and Inman, 1969’, ‘Lee et al., 2011’ and ‘Zatsiorsky, 2002’.

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Descrizione generata automaticamente

Figure ‑: Actual newton Dynamic model.

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