Hip power analysis in individuals with transfemoral amputation: a different strategy from stabilisation during gait stance

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Hip power analysis in individuals with transfemoral amputation: a different strategy different from stabilisation during gait stance

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Introduction and Objectives

Joint moments and joint powers during gait are widely used to determine the effects of rehabilitation programs as well as prosthetic fitting. Following the definition of power (dot product of joint moment and joint angular velocity) it has been previously proposed to analyse the 3D angle between both vectors, αMw. [1]

Basically, joint power is maximised when both vectors are parallel and cancelled when both vectors are orthogonal.

In other words, αMw < 60° reveals a propulsion configuration (more than 50% of the moment contribute to positive power) while αMw > 120° reveals a resistance configuration (more than 50% of the moment contribute to negative power).

A stabilisation configuration (less than 50% of the moment contribute to power) corresponds to 60° < αMw < 120°.

Previous studies demonstrated that hip joints of able-bodied adults (AB) are mainly in a stabilisation configuration (αMw about 90°) during the stance phase of gait. [1, 2] Individuals with transfemoral amputation (TFA) need to maximise joint power at the hip while controlling the prosthetic knee during stance.

Therefore, we tested the hypothesis that TFAs should adopt a strategy that is different from a continuous stabilisation.

The objective of this study was to compute joint power and αMw for TFA and to compare them with AB.

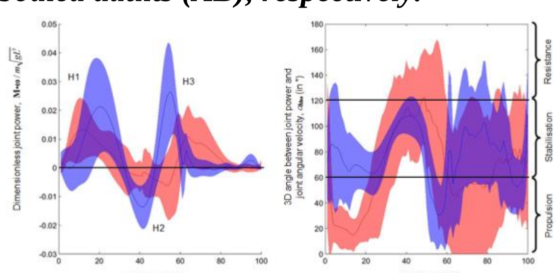
Methods

Three trials of walking at self-selected speed were analysed for 8 TFAs (7 males and 1 female, 46±10 years old, 1.78±0.08 m 82±13 kg) and 8 ABs (males, 25±3 years old, 1.75±0.04, m 67±6 kg). The joint moments are computed from a motion analysis system (Qualisys, Goteborg, Sweden) and a multi-axial transducer (JR3, Woodland, USA) mounted above the prosthetic knee [3-17] for TFAs and from a motion analysis system (Motion Analysis, Santa Rosa, USA) and force plates (Bertec, Columbus, USA) for ABs. The TFAs were fitted with an OPRA (Integrum, AB, Gothengurg, Sweden) osseointegrated implant system and their prosthetic designs include pneumatic, hydraulic and microprocessor knees.[8, 14, 18-23] Previous studies showed that the inverse dynamics computed from the multi-axial transducer is the proper method considering the absorption at the foot and resistance at the knee.[7]

Results

The peak of positive power at loading response (H1) was earlier and lower for TFA compared to AB. Although the joint power is lower, the 3D angle between joint moment and joint angular velocity, αMw, reveals an obvious propulsion configuration (mean αMw about 20°) for TFA compared to a stabilisation configuration (mean αMw about 70°) for AB.

Figure 1: Dimensionless hip joint power (m is the body mass, g is 9.81 m/s2 and L is length length) and 3D angle between joint moment and joint angular velocity: Red and blue lines and areas are means standard deviations for individuals with transfemoral amputation (TFA) and able-bodied adults (AB), respectively.



The peaks of negative power at midstance (H2) and of positive power at preswing / initial swing (H3) occurred later, lower and longer for TFA compared to AB. Again, the joint powers are lower for TFA but, in this case, αMw is almost comparable (with a time lag), demonstrating a stabilisation (almost a resistance for TFA, mean αMw about 120°) and a propulsion configuration, respectively. The swing phase is not analysed in the present study.

Conclusion

The analysis of hip joint power may indicate that TFAs demonstrated less propulsion and resistance than ABs during the stance phase of gait. This is true from a quantitative point of view. On the contrary, the 3D angle between joint moment and joint angular velocity, αMw, reveals that TFAs have a remarkable propulsion strategy at loading response and almost a resistance strategy at midstance while ABs adopted a stabilisation strategy.

The propulsion configuration, with αMw close to 0°, seems to aim at maximising the positive joint power. The configuration close to resistance, with αMw far from 180°, might aim at unlocking the prosthetic knee before swing while minimising the negative power.

This analysis of both joint power and 3D angle between the joint moment and the joint angular velocity provides complementary insights into the gait strategies of TFA that can be used to support evidence-based rehabilitation and fitting of prosthetic components.

Disclosure of Interest

- R. Dumas: None Declared,
- L. Frossard: None Declared,
- C. Robert-Leblanc: None Declared,
- P.-M. Beaulieu: None Declared,
- R. Branemark Conflict with: stock in Integrum. The authors believe that this not of nature to influence their interpretation of the results.

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