

## Defining instances and limbs during performance of the standing turn

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**Abstract**

Conventions have been reported to describe walking and turning gait. No such descriptions appear for the 180° standing turn and as such there are inconsistencies in the literature reporting on this movement. The complexity of explaining the standing turning motion, variation in number of steps when turning, and differing strategies used means conventions will make research reporting easier to comprehend and less likely for errors in interpretation. We propose definitions of the 180° standing turning motion and steps used to complete a turn for able-bodied and pathological populations to encourage consistency in reporting. It is recommended that the definitions be applied in future research on standing turns.

**Keywords:** Turning; Standing; 180° Turn; Step Definitions; Conventions

## **Introduction**

Turning is a common yet complex manoeuvre that occurs whilst in transit and from standing and there is a growing body of research in this area for healthy and pathological gait [1, 2]. Current research on the standing turn has adopted differing approaches to quantifying and describing the turning motion [3, 4]. Developing the principles outlined by Huxham et al. [5] we have devised a convention to define the limbs, features and temporal parameters for turning from standing.

## **Proposed Definitions**

### ***Overall Turn***

The main direction of the turn defines the turn itself. Following this a turn to the right refers to a turn where the whole body moves in a clockwise direction. Conversely a turn to the left refers to a turn where the whole body moves in an anti/counter-clockwise direction.

### ***The Address & Start of the Turn***

The initial position at the start of the turn where they are in double support (DS) shall be referred to as the address (Fig. 1), and should be considered as the period of time between the initiation of the turn and the first movement of a foot which indicates the start of the first step of the turn. This allows any movement due to a preceding task to be distinguished from the start of the turn itself.

The initiation of the turn must be defined specific to any movement occurring during standing prior to the address, the population being investigated, as well as the parameters being studied and motion analysis system used. It is anticipated that through consistent and thorough reporting over time standardised parameters and thresholds to identify the start of the address can be quantified.

### ***Steps Performed during a Standing Turn***

A standing turn will include some or all of the following steps from the initiation to the end of the turn [4] (Fig. 1):

- Preparatory Step
- Turn Step

- Depart Step

\*\*Insert Fig. 1 here\*\*

### ***Defining the Limbs***

Clearly defining the limbs being referred to during a standing turn is important to avoid confusion when interpreting research in this area. The ipsilateral limb is the limb in stance and the contralateral limb is being repositioned during the turn step. Hence, during a right turn the ipsilateral limb will be the left limb and the right limb (contralateral) will be repositioning (Table 1). The proposed definition allows for consistent definitions of the limbs when researching pathological populations or research that stratifies turns according to preference (see below).

\*\*Insert Table 1 here\*\*

### ***Definition of the Preparatory Step Phase***

During the preparatory step the contralateral limb is in stance and the ipsilateral limb is repositioned (Fig. 2). For the turn to the right, the ipsilateral (left) foot is repositioned, and vice versa for a turn to the left.

The repositioning of the ipsilateral limb could be any angular and/or linear displacement of the foot (Fig. 1a, b). To accommodate varying strategies, we use the term repositioning to include swing when the foot leaves contact with the ground (true single support phase), a pivot where one part of the foot remains in contact with the ground while the part not in contact is reorientated, and readjusting where a shuffling movement occurs. It is therefore suggested that the definition of the preparatory step phase should be:

***The step of the turn where the contralateral limb is in stance and the ipsilateral limb is in swing, pivoting or readjusting so that the ipsilateral limb is reorientated from its position during the address.***

**\*\*Insert Fig. 2 here\*\***

In some cases a person may not perform a preparatory step so their first step of the turn following the address will be the turn step (Fig. 1c).

#### ***Turn Step Single Support Phase***

This is the first step of the turn where the ipsilateral limb is in stance and the contralateral limb is repositioning. For a turn to the right, the left limb would be in stance and the right limb repositioning. This is equivalent to the 'step' turn previously defined for steering [6]. It is therefore suggested that the definition of the turn step single support should be:

***The step of the turn where the ipsilateral limb is in stance and the contralateral limb is in swing, pivoting or readjusting.***

Prior to the start of the turn step there will be a period of double support either during the address or from initial contact of the ipsilateral limb to the initiation of repositioning of the contralateral limb. This period represents the initial double support phase of the turn step and the terminal double support of the preparatory step (Fig. 2).

#### ***Depart Step Single Support Phase***

During the depart step a person will be attempting to take the first full step in the intended direction of motion. It is therefore suggested that the definition of the depart step single support should be:

***The first step where a person takes the first full step in the intended direction of motion following completion of the turn. During this step the ipsilateral limb will be in swing or readjusting and the contralateral limb in stance so that at the end of swing or readjustment the toe of the ipsilateral limb should be in front of the toe of contralateral limb, in the direction of travel.***

Prior to the start of the depart step there will be a period of double support from heel-strike of the contralateral limb to the initiation of repositioning of the ipsilateral limb. This period represents the initial double support phase of the depart step and the terminal double support of the turn step (Fig. 2).

#### ***Variation in Strategies used to perform a Standing Turn***

It is possible that the turn will be completed in stages. For example, completing a series of small preparatory and turn steps followed by the depart step (Fig. 1d). Using the above definitions various combinations of preparatory and turn steps can be identified and used to explain the exact nature of the turn.

#### ***Turning Preference***

If a turning preference has been established then the direction of the turn, i.e. to left or right, will be the preferred turn direction. Therefore in line with the above proposed definitions if the preferred turn direction is to the right, it will be from the left foot in turn step stance and reported as the ipsilateral limb.

#### ***Turning and Pathology***

These definitions facilitate the interpretation of the turn in terms of pathology, where it is suggested that the pathology defines the turn rather than the turn defining the limbs. This definition may be used for many pathologies, such as; unilateral amputation, hemiplegic stroke and Parkinsonism. Here the turn is defined by the limb, so a turn is from the affected or unaffected side. Using a unilateral amputee as an example, the ipsilateral limb would be defined as the intact or prosthetic

side as appropriate. Therefore a turn said to be from the intact side will be one where the intact limb is in stance during the turn step.

### **Summary**

We have proposed standardised definitions in relation to limbs and step features of the standing turn to encourage consistency in reporting. These have been considered for able-bodied and pathological populations where one of the limbs is affected.

### **Conflict of Interest Statement**

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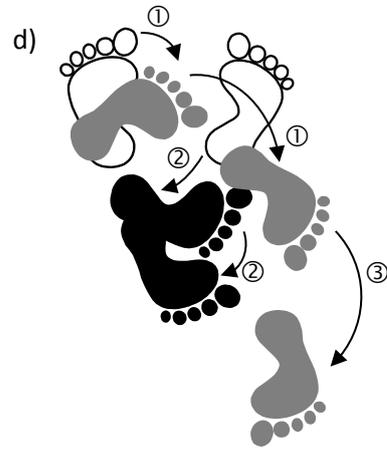
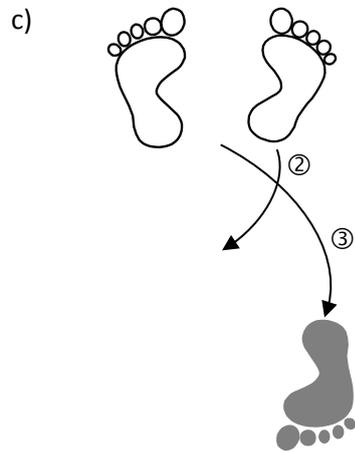
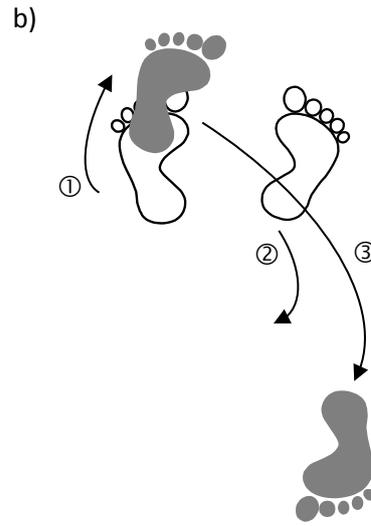
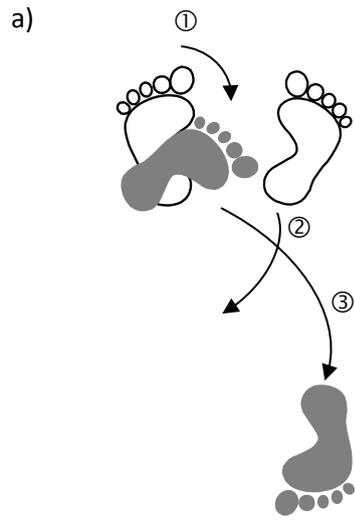
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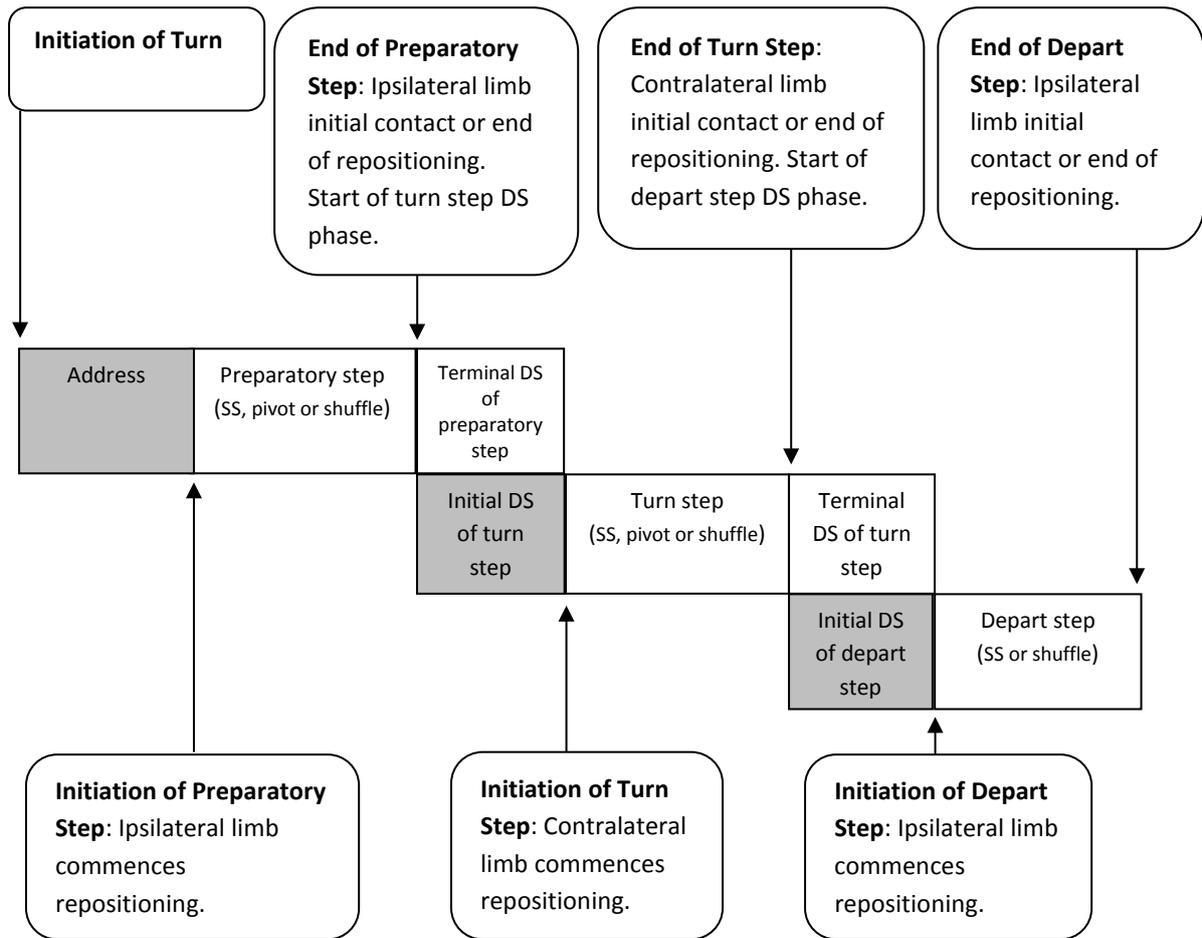
**Table 1:** Definitions of limbs during a standing turn with a preparatory step for a turn to the right and left for able-bodied and left side amputee. The images to illustrate these definitions for a turn to the right are provided in Fig. 1a.

	Turn To Right from the left limb	Turn To Left from the right limb
<b>Able-bodied</b>		
Preparatory step	Right / contralateral limb in stance Left / ipsilateral limb repositioning* Fig. 1a-1	Left / contralateral limb in stance Right / ipsilateral limb repositioning
Turn step	Left / ipsilateral limb in stance Right / contralateral limb repositioning Fig. 1a-2	Right / ipsilateral limb in stance Left / contralateral limb repositioning
Depart step	Right / contralateral limb in stance Left / ipsilateral limb repositioning Fig. 1a-3	Left / contralateral limb in stance Right / ipsilateral limb repositioning
<b>Left side amputee</b>		
Preparatory step	Intact limb in stance (right / contralateral limb) Prosthetic limb repositioning (left, ipsilateral limb) Fig. 1a-1	Prosthetic limb in stance (left / contralateral limb) Intact limb repositioning (right, ipsilateral limb)
Turn step	Intact limb repositioning Prosthetic limb in stance Fig. 1a-2	Prosthetic limb repositioning Intact limb in stance
Depart step	Intact limb in stance Prosthetic limb repositioning Fig. 1a-3	Prosthetic limb in stance Intact limb repositioning

\*The term repositioning indicates; swing, pivoting or readjusting in line with presented definitions to accommodate frail or disabled turners unable to lift the foot off the ground.



**Fig. 1:** A standing turn to the right from the left limb. (a) Illustrates the most common turn strategy in our lab, a turn with a preparatory step, (b) is a small modification of this turn which was relatively common, here the preparatory step involves the forward motion of the ipsilateral limb, (c) illustrates the second most common turn in our laboratory, a turn without a preparatory step, here the ipsilateral limb does not reposition prior to the turn and (d) a turn we have observed with more frail and disabled participants, a preparatory, turn, preparatory, turn, depart strategy. Key: address (white footprints), preparatory (1), turn (2) and depart (3) steps. Definitions of the step pattern for Fig. 1a are provided in Table 1.



**Fig. 2:** Overview of definitions of a standing turn with preparatory step. DS = double support; SS = single support. Note for people who display a shuffling gait they may never have a true single support phase as the feet may shuffle into position. The figure does not indicate scaled temporal aspects of the standing turn cycle.

## Highlights

- Novel definitions of the standing turn have been proposed
- Standardised definitions will aid reporting and interpretation of research
- The proposed definitions of the standing turn apply to various turning strategies
- The proposed definitions of the standing turn can be applied to pathology