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The Paradox of Human Movement: An Observational Study of a Neuro-Musculo-Skeletal Screening Technique, within an Outpatient Physiotherapy Service, Highlighting the Instantaneous Nature of an Asymptomatic, Recovered Movement Pattern as a Behavior

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Abstract

Objective: We can demonstrate the presence of a movement pattern as a behavior for presenting signs and symptoms. This being distinct from a medical aetiology for presenting signs and symptoms. Subsequent to being able to demonstrate the presence of a symptomatic legacy movement pattern behavior causative for presenting signs of symptoms, this enables us to highlight the existence and subsequent access to a paradoxical asymptomatic recovered movement pattern. Both patterns are sensory-based. Instantly demonstrable in self-reporting by the client and observable and testable by the therapist.

Methods: A random consecutive sample of thirty individuals (18 to 82 years) presented to a community physiotherapy musculoskeletal outpatient service, having been referred by their medical practitioner as part of the service pathway. Informed consent was obtained to gather information. Each individual was able to congruently self report their presenting lumbar/lower body signs and symptoms. Collection of audio-visual data in a workshop setting enabled us to both capture and demonstrate functional sit-to-stand movement patterns, presenting (legacy) patterns and the instant recovered pattern for each individual. We chose a within-subject, and within group fully crossed mixed methods study design.

Results: All thirty participants were instantly symptom free and sign free whilst accessing the recovered pattern. We were able to observe and distinguish between a medical and movement pattern aetiology for presenting signs and symptoms for each and every individual. Both movement patterns –legacy and recovered - were congruently self-reported by each participant and objectively testable instantly in real-time by the physiotherapist.

Conclusion: We have demonstrated the clients' ability to access an asymptomatic recovered pattern of movement, subjectively self-reported in sensory-based evidence by the client, and objectively testable by the therapist, in being that change is instant. Therefore, the question of the persistence of the pattern of movement behavior in recovery is more than a question of behavior and capability.

As part of our role as physiotherapists, we are now in a strong position to support the changes in the development of social attitudes, and provide strategies in relation to recovery based on a future orientated outcome model, as opposed to supporting an ongoing acausal limitation in experience for the client.

Keywords: Instantaneous; Recovery; Movement; Self-reporting; Pain; Patterns; Behavior; Equilibrium

Introduction

Context

The paradox of human movement: An observational study of a neuro-musculo-skeletal screening technique, within an outpatient physiotherapy service, highlighting the instantaneous nature of an asymptomatic, recovered movement pattern as a behavior.

The screening technique distinguishes between a medical aetiology and a movement pattern as a behavior for presenting signs and symptoms.

We have found it beneficial to provide some definitions in relation to terminology.

Observation is an active process of gathering information about an ability.

"Ultimately, the process of gathering information about an ability is intended to reveal the patterns of beliefs, thoughts, feelings and behaviors that combine to make that ability possible."

Modeling provides a central role in this observational process. Modeling being defined as "the process of creating useful descriptions of the structure of human abilities." Human experience has structure - significant in relation to both what we are observing and how we are observing the clients physical movement patterns, and also in relation

to client self reporting as a congruent expression for the presence or absence of signs and symptoms within those movement patterns.

All behavior has a neurology. "External Behavior is everything that we do on the outside: Anything that can be seen or heard by someone else, and specifically, when it comes to modeling, only those things that are necessary for an ability to work" [1]. Regardless of it being more or less useful.

"Patterns of movement provide the behavioral expressions of the clients generalizations that form some of the underlying structure of the clients ability" both in the legacy and recovered patterns. This is congruently self-reported by the client.

"A pattern is a combination of two (or more) things relating to one another in a reliable and predictable way" [1].

Legacy pattern is a term we have coined to describe a movement behavior pattern, as being distinct from an adaptive pattern, and as such continues to limit the clients "ongoing" experience un-resourcefully. The legacy patterns original purpose acting as a resource.

Adaptive patterns being distinct from legacy as ecological as part of an ongoing limitation in experience to sustain function, and acting resourcefully.

What is the recovered pattern?

A recovered pattern is the term we use to describe a generic "normal", asymptomatic movement as a behavior.

The recovered pattern both accesses and maintains a moment in equilibrium, as part of a functional movement and can be achieved both statically and dynamically. Testable in this instance as a sit to stand to sit movement.

The recovered pattern being paradoxical in nature. Instantly accessible from within a moment in equilibrium. A homeostatic state.

Within a legacy pattern, the moment in equilibrium lies outside of the client's current awareness, although accessible.

Both the legacy and recovered movement patterns are observable, being distinct neurologically, both in relation to equilibrium and direction of movement.

Clients consistently present to physiotherapy outpatient musculoskeletal services with the belief that they have a medical aetiology, for their current signs and symptoms.

Recent trauma or a chronic condition validating their presentation demonstrably supporting this rationale. This belief can bring with it a number of perceived limitations in relation to outcomes, expectations and treatment pathways for the client and therapist and service providers.

In describing movement pattern behaviors it is important to make a distinction between adaptive patterns and legacy patterns in that legacy patterns are false positives for medical aetiologies.

In demonstrating the existence of a recovered pattern enables the client and therapist to create instant change and as such this is more a question of habituation as opposed to progression of recovery.

Purpose

The purpose of the study was evaluation of a physiotherapy assessment and treatment technique. Highlighting the aetiological determinants for presenting signs, symptoms, and paradoxical recovered movement pattern: An observational study.

The screening technique can distinguish between a medical and movement pattern behavior as an aetiology for presenting signs and symptoms (Figure 1).

Aetiological movement patterns can be instantly highlighted and are consistent with the existence of a paradoxical recovered pattern of asymptomatic movement behavior. We can instantly access this asymptomatic movement (recovered pattern).

Both movement patterns are congruently self-reported by the client and testable objectively by the therapist. This demonstrates the instantaneous nature of change as a recovery process. This presents a new paradigm based on physiological sensory based principles.

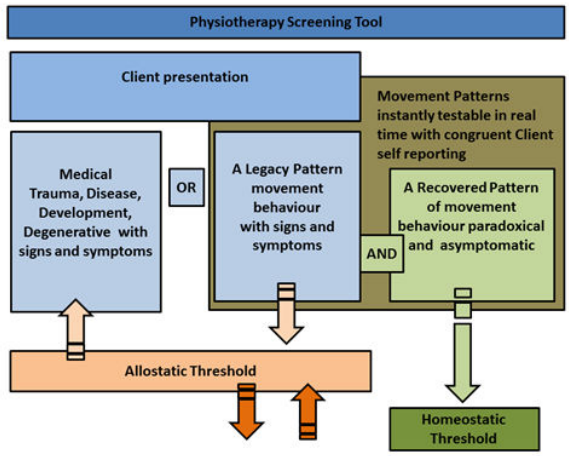

Figure 1: The Screening Technique (The contextual aspects relating to the screening technique and threshold potential and limitation).

The screening technique

Sit to stand is useful both as a functional and a contextual tool for observation and pattern recognition. The forward sit position includes this (Figure 2).

Kapandji describes a sitting position which relies on ischial femoral support with forward lean on arm which reduces shearing forces on the lumbosacral disc and also relaxes the posterior muscles [2].

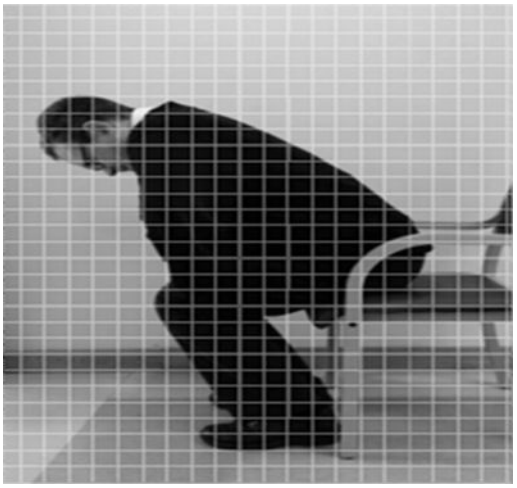

Figure 2A: The Screening Technique-Recovered behavioral pattern of movement.

Figure 2B: The Screening Technique - Legacy behavioral pattern of movement.

Studies investigating the sit to stand task have identified common factors in ease of performance, for example seat height, foot placement and use of arm rests [3-5]. Kinematics of the spine, hip and knee during sit to stand have also been examined [6,7].

It has been identified that subjects with hip osteoarthritis, knee osteoarthritis and low back pain demonstrate altered sit to stand techniques compared to healthy controls [8-11]. Differences in loading and altered weight bearing in the symptomatic joint have been shown [8,12]. From a review of the literature, it seems no study has considered the ability to alter or improve the sit to stand performance, in order to achieve symptom free motion as a functional movement in musculoskeletal subjects.

It would be misleading to consider sit to stand alone, as the screening technique. We have identified and utilize a number of specific components that are used sequentially and simultaneously and integrated from a position in equilibrium directionally. The two movement patterns of legacy and recovery behavior are mutually exclusive.

Neuroplasticity is now becoming a recognized component of musculoskeletal rehabilitation and is significant in the current study [13]. This research study is clinically driven, as a working model. The physical and coaching skills are based on well-established biomechanical principles [14-20].

Methodology

Participants and design

There is complete data reporting in this manuscript [21,22].

A prospective mixed methods (qualitative and quantitative) observational study design was chosen, of a random consecutive sample of individuals. The Clinical Research Ethics Committee of the Cork Teaching Hospitals approved this study. All participants gave written informed consent before data collection began. The clients who were referred as per the referral pathway had equal opportunity to participate in the research study.

Inclusion and exclusion criteria met the normal service criteria, as per standard physiotherapy group work at the venue.

Inclusion criteria, a sample of thirty people of 18 years to 82 years who presented with a variety of lumbar and lower body signs and symptoms, to a community Physiotherapy Service neuromusculoskeletal clinical pathway of care via General Practitioner/medical referral within the current practice parameters.

Exclusion criteria, acute medical conditions - cardiovascular, respiratory; epilepsy; significant cognitive impairment; unpredictable nature of falls history;

Participants attended a group workshop setting at one venue of the Community Physiotherapy musculoskeletal outpatient service in Cork, Ireland. Sample and selection bias of the study design was reduced as much as possible by using the unpredictable recruitment sequence generated by the population of musculoskeletal referrals to the service. The sample size was chosen to ensure a balance between clinical and statistical considerations: management of participants at each study workshop, the use of parametric statistics and enrolment of thirty participants in the time frame of the research project. The dependent sampling design requires fewer study numbers. The clients were recruited by one chartered senior physiotherapist co-investigator.

The service offers clients three workshops, and for the purpose of the study, data was collected from the initial workshop only. Participants were recruited, over five months, to one of six physiotherapy-led audio-visually recorded workshops. Subsequent workshops followed the standard intervention (no audio-visual recording). The study protocol planned in therapists' facilitating participants' health and safety during the workshops.

People were provided with written information enabling them to opt-in two weeks before a study workshop date. They were also given the opportunity to listen to information and ask any questions regarding the study, on the day of the initial workshop, before providing written informed consent to participate. Parallel workshops were planned on the same date and time for any persons changing their choice about participation in the study. However, there was 100%

voluntary participation for the study, by the individuals in the six groups attending initial workshops.

There were no experimental procedures undertaken. The principles and application can be considered within the context of the main body of physiotherapy practice used by physiotherapists versed in neuromuscular motor control. A Toshiba Camileo S20 digital camcorder was placed at a defined distance and position, to record participants' position, movements and pattern in a sagittal plane. A capture setting at 29 frames per second, 1920x1080 pixels in high definition was applied.

Participants were audio-visually recorded for two patterns of movement. The test movements were performed independently. Each participant in the group was asked to stand to sit to stand without instruction (legacy pattern). Afterwards, each participant was asked to perform the technique (recovered pattern) with specific instructions/guidance from the chief investigator (Senior Chartered Physiotherapist) with the use of visual, auditory and kinaesthetic cues during the audio-visual recording of each participant's recovered pattern.

All participants performed two stand-to-sit-to-stand tests.

The study followed a within subject (repeated/two) measures design, each participant acting as their own control. The carry over, fatigue and practice parameters were considered in the context of change, as a resource. The chief investigator was blinded to allocation of participants. There was no blinding of outcome assessment; however the influence of no blinding on the outcome measurement is balanced by the observational and modeling skills and felt sense of the care provider, and participant self-evidence, as the literature notes that knowledge of assigned interventions by participants does not impact on physiological outcomes [23].

Transcripts of audio files (qualitative data) were used for correlation with the images (quantitative data), and audio files were deleted after transcription for agreed anonymity as part of the study protocol. As per study design, the two data sets were compared.

Design for collecting qualitative categorical (nominal) data

A concurrent triangulation design describes how the qualitative data was gathered concurrently with the quantitative data via audio-visual recording [24]. A fully crossed design was chosen for gathering the audio-visual data. Data for all thirty participants was rated by three coders, the chief investigator and two Chartered Physiotherapist co-investigators who were skilled in the application of the screening technique [25]. Each coder independently listened to and confirmed the participant and therapist associated comments in each pattern and verified between all three coders, for the qualitative data collection. This was designed into the study. There was no change of protocol during the study.

Data analysis

The selected recorded image frames were digitally processed to insert a grid overlay onto each of these frames, and processed to create silhouettes. The co-ordinates of each participant's legacy and recovered pattern were highlighted.

Data was analyzed by visually recording and comparing the spatial and temporal differences in movement patterns. We measured, on the sagittal plane with a grid overlay, the lowest x y co-ordinate of their forward-most position of signs and symptomatic legacy pattern (lx,ly), and the lowest xy co-ordinate of their forward-most position in equilibrium of the recovered pattern (rx,ry) in the participants' and therapist's felt sense in experience.

The chief investigator identified and extracted the frames from the time-line for analysis of those co-ordinates lx,ly, and rx,ry per participant and inter-participant correlations for parametric statistical analysis of the legacy pattern lx,ly and the apriori recovered pattern rx,ry . Frames were agreed and confirmed by all three coders.

Information was gathered on differences in individual patterns and data collected of the differences between the individuals in the group, and the association between group participants' recovered pattern. Consideration was given to choices for statistical analytical methods, such as hypothesis testing and estimation of quantified uncertainty, frequentist methods and Bayesian methods [26,27]. The nature of the data precludes the use of analogue measures as the patterns are mutually exclusive one or the other being present at any one time [28-31].

Results

All thirty participants were instantly symptom free and sign free when they accessed their recovered pattern as shown in Figure 3.

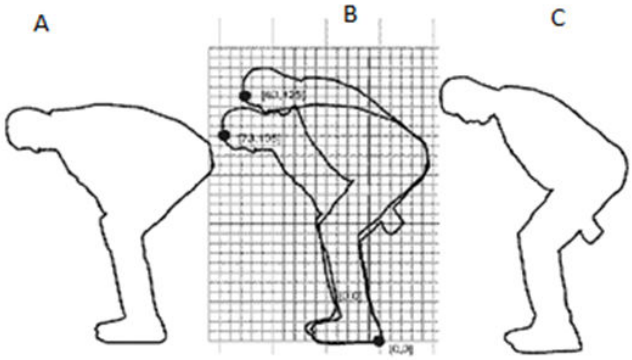

Figure 3: Sample silhouette taken from actual data source depicting A:- Recovered pattern B:- Recovered/Legacy with grid overlay C:- Legacy pattern.

Each individual attending initial workshops participated as shown in Supplementary Figure 1[32].

All participants performed two stand-to-sit-to-stand tests. All participants completed all the test movements. There were no adverse events [33].

The findings of the quantitative and qualitative data sets were integrated to provide evidence to confirm the research question of the presence of a recovered movement pattern (behavior) with no associated symptoms or signs [34]. Table 1 illustrates the study strategy of connecting the two sets of data.

Equal priority is given to the data sets. The data of presenting legacy pattern and recovered pattern was collected as shown in Table 1, assessed for normality as shown in Supplementary Table 1, illustrated, and analyzed as shown in Supplementary Table 2 using a statistical software programme [35].

Participant	(0,0)	Legacy pattern	Legacy pattern	Slope l	Legacy patterns symptoms/ signs	Recovered pattern	Recovered pattern	(0,0)	Slope r	Recovered pattern signs/ symptomfree=0
		lx (cm)	ly (cm)	=ly-0/lx-0	1	rx (cm)	ry (cm)		=0-ry/0-rx	
1	(0,0)	46	135	2.93	1	85	110	(0,0)	1.29	0
2	(0,0)	57	115	2.02	1	79	97	(0,0)	1.23	0
3	(0,0)	38	120	3.16	1	78	105	(0,0)	1.35	0
4	(0,0)	39	115	2.95	1	77	104	(0,0)	1.35	0
5	(0,0)	37	127	3.43	1	80	100	(0,0)	1.25	0
6	(0,0)	17	148	8.71	1	78	95	(0,0)	1.22	0
7	(0,0)	51	133	2.61	1	73	105	(0,0)	1.44	0
8	(0,0)	54	130	2.41	1	83	108	(0,0)	1.3	0
9	(0,0)	38	140	3.68	1	82	97	(0,0)	1.18	0
10	(0,0)	41	133	3.24	1	72	88	(0,0)	1.36	0
11	(0,0)	57	126	2.21	1	87	92	(0,0)	1.06	0
12	(0,0)	53	135	2.55	1	88	108	(0,0)	1.23	0
13	(0,0)	54	113	2.09	1	79	95	(0,0)	1.2	0
14	(0,0)	36	153	4.25	1	83	98	(0,0)	1.18	0
15	(0,0)	49	117	2.39	1	77	95	(0,0)	1.23	0
16	(0,0)	39	142	3.64	1	89	93	(0,0)	1.04	0
17	(0,0)	51	110	2.16	1	86	95	(0,0)	1.1	0
18	(0,0)	43	125	2.91	1	69	92	(0,0)	1.33	0
19	(0,0)	31	149	4.81	1	94	103	(0,0)	1.1	0
20	(0,0)	36	124	3.44	1	82	90	(0,0)	1.1	0
21	(0,0)	42	123	2.92	1	85	94	(0,0)	1.11	0
22	(0,0)	57	130	2.28	1	84	98	(0,0)	1.17	0
23	(0,0)	63	125	1.98	1	73	105	(0,0)	1.44	0
24	(0,0)	38	115	3.03	1	78	95	(0,0)	1.22	0
25	(0,0)	29	135	4.66	1	91	100	(0,0)	1.1	0
26	(0,0)	59	110	1.78	1	91	102	(0,0)	1.12	0
27	(0,0)	48	108	2.25	1	95	95	(0,0)	1	0
28	(0,0)	42	109	2.6	1	82	85	(0,0)	1.04	0
29	(0,0)	52	119	2.29	1	61	101	(0,0)	1.66	0
30	(0,0)	52	119	2.29	1	77	85	(0,0)	1.1	0

Table 1: Raw data co-ordinates of each participant's legacy and recovered pattern.

Notched box plots are presented in Supplementary Figure 2 [36,37].

These variables are chosen to illustrate the directional nature achieved by participants n=30. Full variable reporting is in Supplementary Table 2. Interrater reliability statistics for nominal data with three coders was considered [38].

However, the agreement required was one of confirmation of recorded participant and therapist commentary. The questions and answers of Supplementary Tables 3 and 4 were transcriptions as verbatim and congruent statements time stamped with the clients' screening test. The information was verified by the three coders. Reporting embedded qualitative data of participant-reported important outcomes of symptoms, feeling and function, is relevant for this study and is noted as useful for reviewers of research studies [39].

In information gathering, the emphasis is on a 'now' orientation. 'Now' being when the question is being asked, in legacy pattern and in recovered pattern respectively. This can be considered a congruent report in that moment of time. We are looking for a sensory-based report and not an evaluation.

Client Reporting: Simultaneous symptoms: symptoms present at this moment of asking.

Sequential symptoms: symptoms are present at other times, not present at this moment of asking.

Therapist Reporting: Signs are the observations made by the therapist. What we consider objective indicators based on neuromuscular motor control principles.

What we were evaluating was the congruency of the client self-reporting as a sensory–based experience whilst in either pattern. The data model chosen is 2D Euclidean space recording lx, ly and rx, ry. We recorded two patterns of movement: the recovered pattern from a moment in equilibrium, and the legacy pattern from a moment in a direction (non-equilibrium). Figure 4 highlights the consistency of the moment in equilibrium, both intra and inter-group testing. It also shows the diversity of the legacy patterns.

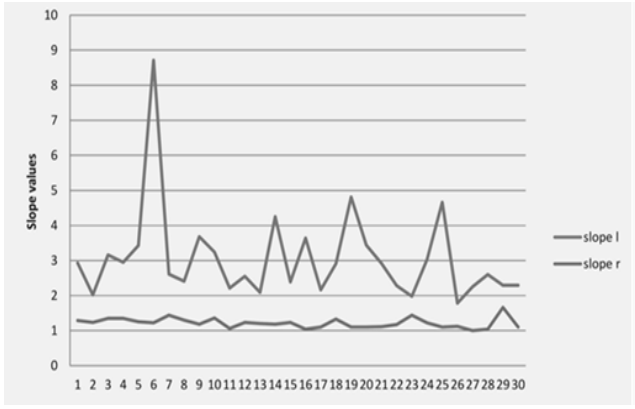

Figure 4: A comparative illustration of presenting patterns graph of slopes between (0,0) and legacy pattern coordinates (lx,ly) slope l, and between recovered pattern coordinates (rx,ry) and (0,0) slope r, of each participant in 2D Euclidean space (n = 30).

Discussion

The screening technique enables us to build an appropriately contextualized intervention based on potential from a movement pattern in recovery as distinct from a threshold as part of legacy pattern aetiology (Supplementary Figure 3).

This research data validates a lumbar and lower body screening technique. In clinical practice we also utilize these principles, clinically in the upper body with consistently similar results as shown in Figure 5.

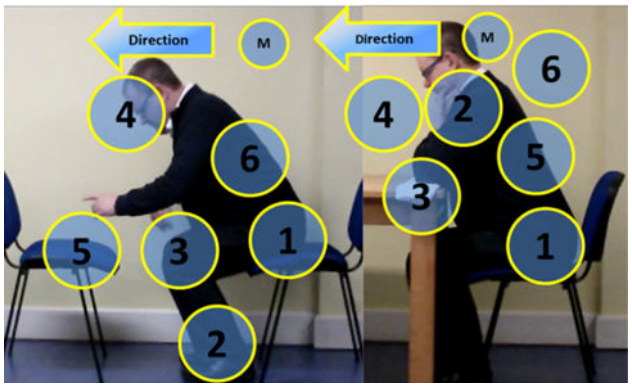

Figure 5: A visual representation of the screening technique both at an upper and lower level. This highlights the principles (components, sequencing, and direction) as a dynamic moment (in equilibrium) of the recovered pattern of movement (behavior).

Change takes time. Based on the evidence of the behavioral aetiology in the study, we have demonstrated that this often is not the case. Due to the instantaneous nature of change, the recovery process becomes a question for `persistence of change` and not `time to change`.

Pushing a legacy pattern threshold as a behavior can now be distinguished from a recovered pattern with potential. This research goes some way in providing the mechanisms underlying current limitations in performance following injury.

Richardson et al. state: 'Indeed, evidence points to a lack of normal recovery, despite a return to normal activity levels' [18].

"Persistence and change need to be considered together, in spite of their apparently opposite nature" [40].

The ability to recover is not so much a question of motivation but habituation. A new paradigm. The holonomic nature of the intervention, observation and pattern recognition requires modeling skills for the therapist. Looking at the internal structure of the clients experience and creating change.

"These high level of clinical skill are necessary to prevent the negative consequences of allowing the patients to perform poor patterns" [19].

This study shows the presence of a recovered moment as part of a recovered pattern of movement behavior. This study has highlighted the distinctions between a behavioral and medical aetiology for presenting signs and symptoms. This study has also demonstrated the instantaneous nature of the screening technique in gaining access to a recovered pattern of movement behavior.

We have highlighted the significance of the sit to stand task both behaviorally and contextually. We chose this functional movement to highlight the presence of the two patterns of movement, as it clearly highlights many clients presenting signs and or symptoms (back pain, lower limb dysfunction, etc.), it also highlights the paradoxical nature

of change and the presence of the recovered pattern; and is presentable across a broad spectrum of the population, not being age or gender specific. The pattern is congruently self-reported in real time.

As part of our work as clinicians there is an imperative that we remove aggravating factors, a movement that is painful can be considered an aggravating factor. We have a duty of care and the study has built out of that duty. Restoring normal movement is also a clinical prerogative and as such the recovered pattern facilitates this. Prevention of further injury, etc. the study is built around a working model, as such is clinically viable. We are describing the structure and components of our work. Our methodologies are more detailed and include a number of strategies that the reader may be unfamiliar with and we would be delighted to provide this work in a future article.

The four primary digital distinctions between the two presenting patterns:

- Recovered pattern and the legacy pattern.
- The presence and absence of a moment in equilibrium.
- The movement direction from position.
- The idiosyncratic (legacy) and generic (recovered) nature of the patterns.

The one thing both patterns have in common:

Both patterns are instantly accessible and physically demonstrable, measurable, observable and testable, and can be congruently self reportable by the client in real time, the study.

It has been recorded that when a moment in equilibrium is accessed, the change is instant and self-evident as a felt sense. This was self-reported.

The client's self-reporting was congruent with their movement pattern behavior as symptomatic or not.

The importance of being able to make a distinction between a medical and behavioral aetiology cannot be overemphasized. The presence of symptoms within a recovered pattern of movement can be considered an indicator for intervention for a medical aetiology.

This distinction facilitates the provision of an appropriately contextualized outcome pathway, with a potential and thresholds as part of a recovery process.

Conclusion

We have demonstrated the clients' ability to access an asymptomatic recovered pattern of movement, subjectively self-reported in sensory-based evidence by the client, and objectively testable by the therapist, in being that change is instant. Therefore, the question of the persistence of the pattern of movement behavior in recovery is more than a question of behavior and capability.

As part of our role as Physiotherapists, we are now in a strong position to support the changes in the development of social attitudes, and provide strategies in relation to recovery based on a future orientated outcome model, as opposed to supporting an ongoing acausal limitation in experience for the client.

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Conflict of Interest Statement

The authors declare no conflicts of interest, no financial or personal relationships with people or organizations that could bias their work.

Authors Agreement/Declaration/Contributions

Each individual named as an author meets the uniform requirements of the Physiotherapy & Physical Rehabilitation criteria for authorship.

All authors made a substantial contribution to the conception and design of this study, acquisition, analysis and interpretation of data, drafting, revising and final approval of this version submitted. Each of the authors has read and concurs with the content in the manuscript. All authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, has not received prior publication and is not under consideration for publication elsewhere.

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Research Data Availability Statement:

The authors declare that the data supporting the findings of this study are available within the paper (and its extended data files and supplementary information files).

Declarations of Interest:

None

Ethics Approval:

The Clinical Research Ethics Committee of the Cork Teaching Hospitals, University College Cork, 6 Little Hanover Street, Cork, Ireland, approved this study. All participants gave written informed consent before data collection began.

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