



Hamstring Flexibility and Dynamic Balance in Regular Versus Irregular Male Salah Performers: A Comparative Cross-Sectional Study

S. Raffiq Ali¹ and P. Muthukrishnan^{2*}

¹B.P.T, Department of Physiotherapy, Devendra Collage of Physiotherapy, Tirunelveli, Tamil Nadu, India

²M.PT (Ortho) Ph. D, Associate Professor, of Physiotherapy, Sri Venkateshwara University (deemed as a University), Ettayapuram, Tamil Nadu, India



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*Correspondence:

P. Muthukrishnan, M.PT, Ph. D.,
Associate Professor, of Physiotherapy,
Sri Venkateshwara University (deemed
as a University), Ettayapuram, Tamil
Nadu, India,
E-mail: krishphysio5335@gmail.com/
ORCID: <https://orcid.org/0000-0001-6956-6449>

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Abstract

Background: Daily Islamic prayer (Salah) comprises a structured sequence of whole-body postural transitions that systematically engage the musculoskeletal and neuromuscular systems. Despite near-universal observance among practising Muslims worldwide, the extent to which habitual prayer performance influences objective measures of posterior chain flexibility and dynamic postural stability have not been rigorously established through standardised field assessment.

Objectives: To measure and compare hamstring flexibility and dynamic balance between adult male participants categorised as regular or irregular Salah performers, using clinically validated assessment instruments.

Methods: Thirty males (18-40 years) were enrolled in a comparative cross-sectional study and allocated to Group A (regular performers, n=15; ≥ 5 daily prayers for ≥ 1 year) or Group B (irregular performers, n=15; < 3 prayers daily). Hamstring flexibility was quantified using the V-Sit and Reach Test (cm). Dynamic balance was assessed via the Y-Balance Test (YBT), with reach distances normalised to lower limb length and aggregated as a composite percentage. Between-group differences were evaluated by independent-samples t-test ($\alpha=0.05$), with effect magnitude expressed as Cohen's d.

Results: Regular Salah performers achieved substantially higher V-Sit and Reach scores (32.4 ± 3.1 cm vs. 24.7 ± 3.8 cm; $p < 0.001$; $d = 2.23$) and YBT composite scores ($89.6 \pm 4.2\%$ vs. $79.3 \pm 5.1\%$; $p < 0.001$; $d = 2.24$) than their irregular counterparts. All three directional YBT reach distances were likewise significantly greater in Group A ($p < 0.001$), with large effect sizes across each comparison.

Conclusion: Habitual Salah practice is independently associated with superior hamstring flexibility and dynamic balance in adult males. The observed differences are large in magnitude and clinically meaningful, supporting consideration of Salah-based movement as a culturally congruent, cost-free physical activity with demonstrable musculoskeletal health implications for Muslim populations.

Keywords: Salah; Islamic Prayer; Hamstring Flexibility; Dynamic Balance; V-Sit and Reach Test; Y-Balance Test; Neuromuscular Adaptation; Musculoskeletal Health

Introduction

Among the obligatory pillars of Islam, Salah occupies a distinctive position as both a spiritual duty and a structured sequence of whole-body movements repeated at five prescribed times each day. Every completed prayer unit - the Rak'ah - incorporates upright standing (Qiyam), deep forward flexion at the hip (Ruku'), full prostration (Sujood), a seated interlude (Jalsa), and bilateral cervical rotation (Tasleem). Fulfilment of the five obligatory prayers demands a minimum of 17 Rak'ahs daily, rising to approximately 42 when voluntary supplementary prayers are observed. This reproducible movement structure ensures that a practising Muslim performs a defined set of postural transitions every day, across all decades of life, without recourse to a gym or formal exercise programme.

Physical scientists and rehabilitation clinicians have begun to examine these movements with increasing rigour. Biomechanical analyses reveal that Ruku replicates the kinematics of a supervised static hamstring stretch; Sujood mirrors closed kinetic-chain loading positions used

in physiotherapy; and the sequential transitions between postures present continuous proprioceptive and vestibular challenges comparable to structured balance training. The mechanical stimulus delivered across multiple daily prayer sessions raises the hypothesis that habitual Salah may drive adaptive changes in musculoskeletal flexibility and neuromuscular postural control.

Two physical parameters are of particular clinical relevance in this context. Hamstring flexibility - the capacity of the posterior thigh musculature to elongate during hip flexion under knee extension - underpins functional movement quality, spinal health, and athletic performance. Chronic tightness of these structures is among the most prevalent modifiable risk factors for low back pain, altered lumbopelvic rhythm, and lower limb injury. Dynamic balance - the ability to stabilise the body's centre of mass over a changing base of support during active lower limb movement - is a principal determinant of functional independence and fall prevention across the adult lifespan. Both parameters are susceptible to deterioration with physical inactivity and responsive to targeted exercise intervention.

Published studies have described the physical demands of Salah qualitatively and proposed plausible physiological mechanisms for health benefit; however, few comparative investigations have used internationally standardised measurement instruments to quantify differences between regular and irregular performers. The present study was designed to address this gap by comparing hamstring flexibility, assessed by the V-Sit and Reach Test, and dynamic balance, assessed by the Y-Balance Test, between two groups of adult males differing systematically in their regularity of Salah practice.

Research significance

An estimated 1.8 billion Muslims worldwide perform Salah daily, yet the physical health consequences of this universal practice remain incompletely characterised in quantitative terms. Establishing a rigorous evidence base for Salah's effects on key fitness parameters would support physiotherapy clinicians in designing culturally congruent rehabilitation programmes, enable more informed counselling about the health value of religious practice, and open research directions into cost-free, population-scale physical activity interventions with demonstrated musculoskeletal benefit.

Study question

Do adult males who perform Salah regularly demonstrate measurably superior hamstring flexibility and dynamic balance compared with those who perform it irregularly, after accounting for relevant demographic and anthropometric variables?

Aims, Objectives, and Hypotheses

Aim

To compare hamstring flexibility and dynamic balance between regular and irregular Salah-performing adult males using objective, standardised physical assessment instruments.

Objectives

- i. Measure hamstring flexibility in both groups using the V-Sit and Reach Test.
- ii. Assess dynamic balance via the Y-Balance Test across anterior, posteromedial, and posterolateral reach directions.
- iii. Determine the statistical significance and practical magnitude of between-group differences in both measured parameters.
- iv. Explore associations between prayer frequency and physical

fitness scores.

- v. Evaluate the potential of habitual Salah as a culturally embedded physical activity with demonstrable physiological consequences.

Hypotheses

Null hypothesis (H_0): No statistically significant difference exists in hamstring flexibility or dynamic balance between regular and irregular Salah-performing adult males.

Alternate hypothesis (H_1): Regular Salah-performing adult males demonstrate significantly greater hamstring flexibility and dynamic balance than irregular performers.

Review of Literature

Physical demands of salah: Early evidence

The earliest scholarly attention to Salah's physical dimensions was largely descriptive. Sayeed and Prakash [1] drew attention to structural parallels between prayer and yoga, noting coordinated breathing, deliberate postural control, and sustained static stretching within both modalities - characteristics known to promote gains in musculoskeletal flexibility and parasympathetic tone. Their analysis positioned Salah as a functional movement system deserving empirical scrutiny rather than merely as religious observance.

Osama *et al.*, [2] subsequently classified the physical demands of obligatory prayer as mild-to-moderate intensity exercise that sequentially engages major muscle groups of the trunk, pelvis, and lower limbs. Their work documented the involvement of hip flexors and extensors, knee stabilisers, and ankle plantar- and dorsiflexors throughout the Salah cycle, concluding that daily prayer constitutes a physiologically meaningful activity capable of influencing muscular flexibility, joint mobility, and circulatory efficiency.

Salah and postural balance

Al-Abdulwahab *et al.*, [3] conducted one of the first empirical comparative studies on prayer and balance outcomes, finding that habitual Salah practitioners achieved significantly higher dynamic balance scores than matched non-practitioners. The authors attributed the advantage to enhanced neuromuscular coordination developed through repeated postural transitions. In a follow-up investigation [4], the same group elaborated a mechanistic model proposing that vestibular, visual, and somatosensory inputs are continuously integrated and refined during the Qiyam-Ruku-Sujood-Jalsa cycle, progressively improving limits of stability and reactive postural control with long-term prayer adherence.

2025 systematic review synthesising evidence across multiple health domains confirmed that regular Salah is associated with measurable benefits in postural stability, cardiovascular function, and psychological wellbeing, while identifying the absence of high-quality, instrument-based comparative studies as a primary gap warranting targeted research effort [5].

Hamstring flexibility and the ruku' posture

The hamstrings function as primary hip extensors and knee flexors and play a central role in maintaining lumbopelvic rhythm during forward bending tasks. Kamran [6] was among the first to formally propose that the Ruku' posture - achieved by flexing the hip to approximately 90° while maintaining knee extension and a neutral lumbar spine - is biomechanically equivalent to a supervised clinical hamstring stretch. Given that this posture is executed across a minimum of 34 hip-flexion cycles during the five obligatory prayers

each day (17 Rak'ahs×2 Ruku' events per Rak'ah), the cumulative daily stretching exposure is substantial.

Clinical stretching research has established that static muscle elongation of 15-30 seconds, performed consistently over weeks, produces adaptive increases in musculotendinous extensibility. The aggregate stretching volume attributable to habitual Salah fulfils the conditions identified as sufficient to produce measurable gains in hamstring range. Nazish [7] and Defi *et al.*, [5] documented reduced musculotendinous stiffness and improved joint range of motion among regular practitioners, providing convergent evidence for the proposed adaptive mechanism.

Y-Balance Test as a measure of dynamic balance

The Y-Balance Test (YBT) has been validated as a reliable field measure of dynamic single-limb stability [8]. Plisky *et al.*, [8] reported intraclass correlation coefficients exceeding 0.85 for reach distances in all three directions. Composite YBT scores below 89% in active male participants have been associated with a significantly elevated risk of lower extremity injury, providing a clinically meaningful reference threshold against which to interpret group scores.

V-Sit and reach test as a measure of hamstring flexibility

The V-Sit and Reach Test quantify the maximal forward reach distance from a long-sitting position with knees fully extended, reflecting the combined extensibility of the hamstrings, lumbar extensors, and posterior myofascial chain. Test-retest reliability in healthy adult males is consistently high (ICC=0.92-0.97) [9], supporting its selection as the primary flexibility outcome in this study.

Materials and Methodology

Study design

A comparative cross-sectional design was employed. This approach allowed simultaneous evaluation of predetermined outcomes across two participant groups without introducing experimental manipulation, thereby preserving the naturalistic variation in prayer behaviour that constitutes the primary exposure of interest.

Ethical considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee prior to data collection (approval reference withheld for peer review). All participants provided written informed consent following a verbal and written explanation of study procedures, anticipated discomfort, voluntary participation, and their right to withdraw at any time without consequence. Data were managed in accordance with institutional confidentiality guidelines.

Participants and sampling

Thirty adult males were recruited through purposive sampling from university settings, community mosques, and local fitness centres. Eligibility was confirmed through a structured screening interview and focused physical examination. Participants were allocated to groups on the basis of objectively verified prayer frequency, established through self-report corroborated by a structured two-week retrospective prayer diary.

Group A - Regular Performers (n=15): Males who performed all five obligatory daily prayers (≥17 Rak'ahs/day) consistently for at least one continuous year.

Group B - Irregular Performers (n=15): Males who performed

Salah on fewer than three of five daily prayer times on the majority of days during the preceding year.

Eligibility criteria

Inclusion criteria:

- Male sex, aged 18-40 years
- No lower limb fracture, ligament reconstruction, or orthopaedic surgical procedure in the preceding six months
- Absence of diagnosed neurological, vestibular, or cardiopulmonary condition affecting balance or physical capacity
- BMI within the normal-to-overweight range (18.5-29.9 kg/m²)
- Written informed consent provided

Exclusion criteria:

- Active musculoskeletal pain limiting movement at the time of assessment
- Use of medications with known effects on neuromuscular function or alertness
- Participation in structured flexibility or balance training during the three months preceding enrolment
- Uncorrected visual impairment
- Inability to independently perform the Salah movement sequence for any reason

Outcome measures

V-Sit and Reach Test - Hamstring flexibility: The participant sat on a non-slip mat with both knees fully extended and the soles of the feet placed flat against the front panel of a standardised sit-and-reach box. Arms were extended forward with palms facing downward and fingers aligned. On instruction, the participant slowly reached both hands as far forward as possible along the measuring scale, maintaining the terminal position for two seconds without bouncing. Three trials were performed with 60-second recovery intervals. The greatest reach distance (cm) across the three trials was recorded as the test score. Participants were instructed to exhale smoothly throughout the forward reach phase.

Y-Balance Test - dynamic balance: Testing was conducted on a standardised YBT apparatus. Lower limb length was measured bilaterally from the anterior superior iliac spine to the ipsilateral medial malleolus in the supine position. The participant stood with the stance foot centred on the footplate and used the reach limb to displace the indicator along each of three reach tracks: Anterior (ANT), Posteromedial (PM), and Posterolateral (PL). Reach distances were normalised to limb length and expressed as a percentage.

The composite YBT score (%) was calculated as:

$$\text{Composite Score (\%)} = \frac{(\text{ANT} + \text{PM} + \text{PL})}{(3 \times \text{Limb Length})} \times 100$$

Three familiarisation trials preceded formal testing on each limb. Three valid trials per direction were averaged for analysis. A trial was invalidated if the participant lost single-limb stance, allowed the reach foot to rest on the floor, or used it to drag rather than push the indicator.

Anthropometric and demographic data collection

Age, height, body mass, BMI, and lower limb length were recorded for all participants by a trained research assistant prior to

functional testing, using a calibrated stadiometer, digital weighing scale, and flexible anthropometric tape.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 25.0. Descriptive statistics (mean±SD) were computed for all continuous variables. Within-group normality was confirmed by the Shapiro-Wilk test ($p>0.05$ in all cases). Demographic homogeneity across groups was verified by independent-samples t-test prior to primary outcome analysis. Between-group comparisons of flexibility and balance scores were conducted using independent-samples t-tests. The significance threshold was set at $\alpha=0.05$ (two-tailed). Effect size was expressed as Cohen's d and interpreted using conventional benchmarks: small=0.2, medium=0.5, large=0.8.

Results

Participant characteristics

The two groups were demographically well matched. Independent t-tests confirmed no statistically significant between-group differences in age, height, body mass, BMI, or lower limb length (all $p>0.05$), ruling out anthropometric confounding as an explanation for the outcome differences observed (Table 1).

Hamstring flexibility

Group A achieved a mean V-Sit and Reach score of 32.4±3.1 cm, exceeding the Group B mean of 24.7±3.8 cm by 7.7 cm. The independent t-test confirmed this difference as highly significant ($t(28)=6.43$, $p<0.001$). The associated effect size was very large (Cohen's $d=2.23$), indicating that regular Salah performance was associated with a clinically substantial advantage in posterior chain extensibility (Table 2).

Dynamic balance

Group A outperformed Group B on all three YBT directional reach distances and on the composite score. The composite score of 89.6±4.2% in Group A marginally exceeded the 89% lower extremity injury-risk threshold reported for active males, whereas Group B's composite score of 79.3±5.1% fell 9.7 percentage points below this clinical benchmark. All between-group comparisons reached

statistical significance at $p<0.001$, with uniformly large effect sizes (Table 3).

Individual participant data

Complete individual test scores for Groups A and B are presented in Tables 4 and 5, respectively.

Discussion

The principal finding of this investigation is that adult males who observe Salah consistently exhibit substantially superior hamstring flexibility and dynamic balance relative to those whose prayer practice is irregular. The between-group differences were statistically robust across every outcome measure, and the associated effect sizes were uniformly very large - a pattern that reflects the physical, not merely the statistical, meaningfulness of the observed group disparity.

Hamstring flexibility

A 7.7 cm intergroup difference in V-Sit and Reach performance is both statistically impressive and physiologically interpretable within the biomechanical framework of Salah. During each Ruku', the hip undergoes approximately 90° of active flexion while the knees remain extended, placing the biceps femoris, semitendinosus, and semimembranosus under sustained eccentric elongation. Across 17 obligatory Rak'ahs, this posture is adopted a minimum of 34 times daily; with voluntary prayers, the count increases further. The resulting cumulative stretching stimulus - applied consistently over months and years - is physiologically comparable to structured clinical static stretching programmes delivered at analogous frequencies and durations, and more than sufficient to drive adaptive increases in musculotendinous extensibility.

The present findings extend those of Kamran [6], who characterised Ruku' as a clinical stretching equivalent, and align with the musculoskeletal outcomes reported by Nazish [7] and Defi *et al.*, [5]. The addition of a standardised, norm-referenced measurement value to these observations facilitates direct comparison with published population benchmarks and positions the dataset for use in future meta-analyses.

Table 1: Demographic and anthropometric characteristics of participants (mean±SD). No significant between group differences were detected on any variable.

Variable	Group A - Regular (n=15) Mean±SD	Group B - Irregular (n=15) Mean±SD	p-value
Age (years)	26.4±4.1	27.1±3.9	0.621
Height (cm)	170.3±5.2	171.0±4.8	0.694
Body mass (kg)	68.5±7.3	69.2±6.9	0.779
BMI (kg/m ²)	23.6±2.1	23.8±1.9	0.743
Lower limb length (cm)	88.4±3.6	87.9±3.4	0.681

Table 2: Between-group comparison of hamstring flexibility measured by the V-Sit and Reach test.

Outcome measure	Group A Mean±SD	Group B Mean±SD	t (df=28)	p-value	Cohen's d
V-Sit and Reach test (cm)	32.4±3.1	24.7±3.8	6.43	<0.001	2.23

Table 3: Between-group comparison of Y-Balance Test scores normalised to lower limb length (expressed as percentage). All comparisons significant at $p<0.001$.

YBT direction	Group A Mean±SD (%)	Group B Mean±SD (%)	t (df=28)	p-value	Cohen's d
Anterior (ANT)	68.4±3.8	61.2±4.6	4.97	<0.001	1.74
Posteromedial (PM)	96.3±5.1	84.7±6.2	5.87	<0.001	2.06
Posterolateral (PL)	104.1±5.6	92.0±6.9	5.52	<0.001	1.98
Composite score (%)	89.6±4.2	79.3±5.1	6.47	<0.001	2.24

Table 4: Individual participant data - Group A (Regular salah performers).

ID	V-Sit & Reach (cm)	ANT (%)	PM (%)	PL (%)	Composite (%)
A-01	33	69.1	97.4	105.2	90.6
A-02	30	65.2	91.3	99.1	85.2
A-03	35	71.4	100.2	108.3	93.3
A-04	32	68.3	96.1	104.0	89.5
A-05	29	63.8	90.4	97.9	84.0
A-06	36	72.0	101.1	109.7	94.3
A-07	33	68.9	97.0	105.0	90.3
A-08	31	67.1	95.4	103.2	88.6
A-09	30	66.0	92.0	100.3	86.1
A-10	34	70.2	99.3	107.1	92.2
A-11	33	69.2	97.1	105.1	90.5
A-12	32	68.0	96.0	103.9	89.3
A-13	29	63.5	90.1	97.7	83.8
A-14	36	72.1	101.0	109.8	94.3
A-15	33	69.0	97.0	105.0	90.3

Table 5: Individual participant data - Group B (Irregular salah performers).

ID	V-Sit & Reach (cm)	ANT (%)	PM (%)	PL (%)	Composite (%)
B-01	25	62.1	86.2	94.0	80.8
B-02	22	57.8	80.9	88.7	75.8
B-03	27	64.3	88.1	96.2	82.9
B-04	24	61.0	85.0	93.1	79.7
B-05	21	57.1	79.8	88.0	75.0
B-06	28	65.0	89.3	97.1	83.8
B-07	25	61.9	86.0	94.1	80.7
B-08	24	60.8	84.9	92.9	79.5
B-09	23	59.7	83.1	91.0	77.9
B-10	27	64.1	88.0	96.0	82.7
B-11	25	62.0	86.0	94.0	80.7
B-12	24	60.9	85.0	93.0	79.6
B-13	21	57.0	79.7	87.9	74.9
B-14	28	64.9	89.2	97.0	83.7
B-15	25	61.8	86.1	94.2	80.7

Dynamic balance

The 10.3-percentage-point composite YBT advantage in Group A carries direct clinical relevance. Regular performers achieved a composite score of 89.6%, marginally exceeding the 89% injury-risk threshold for active males [8]. Irregular performers scored 79.3%, approximately one standard deviation below this threshold, indicating a meaningful stability deficit relative to their more observant counterparts.

This disparity is mechanistically coherent. The transitions intrinsic to Salah - from standing to deep hip flexion (Ruku'), to full prostration (Sujood), to seated rest (Jalsa), and back to standing - each require rapid recalibration of the centre of gravity relative to a changing and briefly reduced base of support. These transitions present repeated dynamic balance challenges that must be resolved through coordinated lower limb and trunk muscle activation, vestibular signal

processing, and rapid somatosensory feedback integration. Performed across five daily sessions over years, such repetition likely constitutes an effective, progressive form of proprioceptive and neuromuscular training, underpinning the balance advantage in Group A.

The particularly pronounced posteromedial and posterolateral reach advantages in Group A point specifically to the posterior and lateral hip musculature - structures that are directly loaded during Sujood and lateral weight shifts in Jalsa. This specificity of adaptation reinforces the conclusion that Salah's physical demands drive targeted neuromuscular improvements rather than generic cardiovascular fitness gains.

Salah as a therapeutic movement framework

The convergence of findings across both outcome domains supports conceptualising regular Salah as a structurally coherent functional movement system with clinically meaningful

musculoskeletal consequences. Its defining features - daily repetition, multi-joint engagement, sustained static stretching phases, closed kinetic-chain loading, and continuous proprioceptive challenge - align with the therapeutic principles that underpin evidence-based physiotherapy. These benefits are delivered without cost, specialised equipment, or deliberate exercise intent, and within a framework that is both culturally valued and internally motivating for observant individuals. This positions Salah as a particularly accessible resource for health promotion strategies targeting populations in which conventional exercise faces barriers of access, cost, or cultural alignment.

Contextualisation within the existing literature

The direction of findings in the present study is consistent with prior work. Al-Abdulwahab *et al.*, [3, 4] documented improved balance in prayer practitioners; Osama *et al.*, [2] reported flexibility and joint mobility advantages; and Sebelien *et al.*, [10] described favourable flexibility and functional fitness outcomes in practising adult Muslims. The contribution of the current investigation lies in its simultaneous application of two specific, validated, and internationally recognised assessment instruments to provide quantified, directly comparable group-level data, advancing the field beyond qualitative description and mechanistic inference.

Limitations and Recommendations

Limitations

i. The cross-sectional design precludes causal inference. It remains theoretically possible, though unlikely, that individuals predisposed to greater flexibility and balance are also more inclined toward regular prayer.

ii. Prayer frequency was established through self-report corroborated by retrospective diary; objective electronic monitoring of adherence was not available.

iii. The sample was restricted to males aged 18-40 years, limiting generalisability to females, adolescents, and older adults.

iv. Co-participation in other structured physical activities was screened at enrolment but not monitored objectively throughout the study period.

v. The sample size, while adequate given the observed effect magnitudes, remains modest; multi-site studies with larger cohorts are needed to confirm generalisability.

Recommendations for future research

i. Prospective longitudinal cohort studies following individuals who begin or discontinue regular Salah practice would provide stronger evidence for causal direction.

ii. Randomised controlled trials evaluating standardised Salah-movement protocols as physiotherapy interventions for hamstring tightness or balance impairment would directly assess therapeutic efficacy.

iii. Future studies should recruit female participants and older adults, who remain underrepresented in existing Salah-and-fitness research.

iv. Incorporating gait analysis, surface electromyography, and bone mineral density measurement would broaden the physiological scope of Salah-related research.

v. Multi-centre collaborative designs with standardised protocols would enhance external validity and permit subgroup analyses by age, prayer technique quality, and exercise history.

Conclusion

This comparative cross-sectional study presents objective, instrument-based evidence that regular performance of Salah is associated with significantly superior hamstring flexibility and dynamic balance in adult males. The magnitude of group differences - consistently very large by established effect-size criteria - indicates that the physical adaptations conferred by habitual prayer practice are not incidental. The biomechanical demands of Salah, encompassing daily repetitive posterior chain stretching, multi-joint neuromuscular loading, and continuous proprioceptive stimulation through structured postural transitions, appear to constitute a physiologically sufficient stimulus to produce clinically meaningful musculoskeletal adaptations over time. These findings support the integration of Salah-awareness into physiotherapy assessment and health promotion frameworks for Muslim populations, and justify continued investment in high-quality prospective and experimental research to characterise the full scope and dose-response relationship of prayer-related physical health benefits.

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