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Development of Muscle Function & Protein Intake Score Card; A Web Based Nutrition Assessment Application for Dietitians

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KEYWORDS

Muscle function, Hand grip strength, calf circumference , strength training ,Nutrition Assessment

ABSTRACT:

Background: Muscle Function Protein Score (MFPS) is the first nutrition assessment tool developed for practising dieticians that integrates and quantifies nutrient intake with other variables such as physical activity, hand grip strength and calf circumference. MFPS is a quick digital web-based application designed and tested for it's reliability to predict sarcopenia (loss of muscle mass and strength). It is a simple tool that provides a risk score with nutritional status. The score is auto generated which helps to devise a comprehensive nutrition care plan.

Objective: This study examined the reliability of the web-based application by a Dietitian in a clinical setting and provide a digital tool to generate the risk score to assess the nutritional status of the patients

Methods: 632 healthy participants visiting health check-up department of tertiary care hospital were screened. 604 participants cconsented to undergo detailed Nutritional assessment including Body Mass Index, Hand Grip Strength (HGS) of both dominant and non-dominant hands, calf circumference and Energy, Protein, Fat & Carbohydrate were estimated with the 24-hour diet recall The data collected was applied based on standard reference values, and screening criteria for obtaining the risk scores.

Results: The web-based application was statistically tested to ensure the reliability using cronbach's alpha which increased significantly to 0.955 indicating excellent internal consistency while tested on a sample size of 604 participants , suggesting that as the hand grip strength decreases, the risk indicated by the muscle function protein score increases while this association is stronger than for any of the other variables examined. Hand grip strength of both the hands showed a statistically significant association with the muscle function protein risk score obtained.

Conclusion: MPFS is user friendly and developed such that the domain does not save any data or input provided by the user hence thereby safe guarding the privacy of the client's data as well as that of the user.The developed web-based application is a reliable digital tool that can be used to generate the risk score for loss of muscle function correlating it with the dietary intake of protein and physical activity that providing a comprehensive report for practising dietitian to help her to improving the nutritional status of patients assessed ,also helps to recommend any further nutritional assessments techniques required to be carried out s body composition analysis and biochemical investigations , to plan a comprehensive nutrition care plan.

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Introduction :

Muscle function and strength are critical components of overall health. Higher muscle strength correlates with improved physical function, as evidenced by studies showing significant associations between maximal strength and performance in tasks like sit-to-stand and gait speed (KINOSHITA, 2022). Muscle strength, rather than muscle mass, is a better predictor of cognitive function in older adults. A study found that muscle strength explained a larger variance in cognitive performance than muscle mass (Storoschuk, 2023).In individuals with spinal muscular atrophy (SMA) and Duchenne muscular dystrophy (DMD), muscle strength is strongly linked to motor function, with declines in strength corresponding to declines in functional abilities (Wijngaarde, 2020) (Nunes, 2016). It is vital to screen , assess and early intervention is necessary to attenuate further breakdown of muscle with improved technique which is more comprehensive method of assessment involving all three criteria such as physical activity and diet. Nutrition assessment tools for outpatients are essential for identifying malnutrition risk among patients visiting at out-patient setting.

Muscle Function Protein Score (MFPS) is a quick assessment tool that is designed to predict Sarcopenia which is a progressive loss of muscle mass and strength (Nivine I Hanach , 2019) among healthy adults. It is a simple tool designed for Clinical Dietitians to record theimacro-nutrient intake of their patient, assess muscle function, capture physical activity pattern and calf circumference through which a final score is auto generated with the report that can be used as an important tool to counsel patient and further assessment involving body composition, biochemical parameter can be suggested through which nutrition care plan can be devised accordingly.

Particularly patients treated at outpatient clinics, screening tools should be a non-invasive, simple that can be rapidly performed (Carlos, 2022).

This tool can be used by Dietitian every week during regular follow up since patients are not subjected to weekly lab tests or body composition tests which can be impractical or expensive in most clinical setting.

This is a web based application that is unique as it quantifies macronutrient intake , used as one of the criteria for scoring and emphasizes on daily protein intake as per the preferred body weight (adjusted body weight/Ideal body weight/ Actual or Current Body Weight) that can be used to generate a comprehensive report to interpret results to patients. All other nutrition screening tools used globally such as GLIM , MUST , NRS 2002 , MNA ,etc involves intake of nutrient as one of scoring criteria but does not quantify the actual intake of macronutrients / protein intake and precisely nutrients are not calculated . It helps to early identify those nutritionally at risk and helps to predict any underlying condition associated with sarcopenia or functional loss.

A team of Dietitians, Academicians, Doctors are involved in designing and validating the tool as we were in need to create a screening tool involving nutrient intake and correlating it with calf circumference, muscle function and activity scores which can predict nutrition risk among patients.

Material and Methods:

We screened 632 healthy participants visiting health check up department of tertiary care hospital out of which only 604 samples accepted to undergo detailed assessment such as Body Mass Index, Hand Grip Strength (HGS) of both dominant and non-dominant hand , calf circumference and 24 hour diet recall through which macronutrient was estimated which involved daily intake of protein . The data was applied based on standard cut off reference values ,screening criteria for risk scores.

The tool provides a score against each parameter based on reference values and cut-off range as per research data. The lowest risk score is between 0-2 but the highest is 7 which is considered as high risk. The final score obtained between 0 to 2 may require re-screening after 12 weeks but the score equivalent to or more than 3 needs further attention from the Clinical Dietitian who can take a decision along with the treating Doctor to subject the patient to further comprehensive nutrition assessment.

The web based application has been applied on 632 healthy adults with a sample size of 270 male and 362 female of age group 18-60 years , walking into health check -up department at a tertiary care hospital at Bengaluru North.

The tool involves scoring of the following data :

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1. **Hand Grip Strength(kg) involving both dominant and non-dominant hand**
2. **Calf Circumference (cm)**
3. **Physical activity level (active /moderate/poor)**
4. **Intake of protein in gram (less than 0.8 , more than 0.8- 1g & >1g/kg body weight)**

The final report also captures other information that can be used for counselling the patient such as :

1. **Name**
2. **Age (years)**
3. **Contact Number for identity**
4. **Food preference : Mixed diet / Vegan / Ovo-vegetarian / Lacto-vegetarian**
5. **Body Mass Index (kg/m^2)**
6. **Ideal body weight/ Adjusted body weight**
7. **Nutrient intake** – Energy (kcal) , Protein(g), Carbs(g), Fat (g)
8. **Final Remarks by Consulting Dietitian can be updated.**

Criteria Used for Scoring :

1. **Hand Grip Strength(kg) involving both dominant and non-dominant hand:**

Hand grip strength (HGS) serves as a vital indicator of overall health and functional capacity in adults. Recent studies reveal significant trends and associations between HGS, age, gender, and quality of life. Notably, a decline in HGS has been observed, particularly among males, suggesting a potential deterioration in general health over time. According to a Shanghai study, the mean adjusted HGS decreased somewhat but significantly between 2000 and 2020, with men suffering a 2.8-fold larger loss than women (Wang et al., 2024).

It is important to keep in mind that programs targeted at increasing muscle strength could improve quality of life, especially in older populations, even while the fall in HGS raises worries about adult health. This dual emphasis on health and power could offer a strategy to counteract the noted drops in HGS.

The decrease in HGS can be a reflection of more general health problems in the community, highlighting the necessity of muscle-strengthening therapies. A normative grip and pinch strength values are used to evaluate the impact of treatment, gauge a patient's initial limitations, and establish a starting point for future evaluations of the patient's development. Due to differences in genetic, environmental, and nutritional factors, data collected from western populations cannot be utilized as a reference in Indian communities, hence an Indian study provides us a reference cut off value for healthy Indian adults . This is a descriptive study which involved

1005 healthy adults were selected as a convenience sam ple used

grip strength at 0° of elbow flexion, men's grip strength levels ($p \leq 0.001$) were substantially higher than women .**The average grip strength reference values used for scoring are 20 kg for women and 33 kg for males (Rajani P Mullerpatan , 2013). Normal hand grip is considered as 0 but weak grip strength as 1 as scoring system in application.**

2. Calf Circumference (cm) :

In several health evaluations of Indian communities, cal f circumference (CC) has become a significant anthropo metric parameter, especially when it comes to sarcopeni a

and low birth weight (LBW).It's potential for wider ther apeutic application highlighd by recent studies that conf irm its usefulness as a trustworthy measure of muscle m ass and newborn health.According to a study conducted on postmenopausal women, a CC cutoff of 32 cm was 1 00% sensitive and 80% accurate in identifying sarcopen ia

(Malik & Goel, 2024).This implies that CC can be a use ful instrument for determining

muscle mass in clinical setting which is simple and easy to carry out.

Calf circumference is a straightforward and reliable surr ogate measurement of muscle mass for sarcopenia diagn osis, and it has a favorable correlation with BIA- and D XA-

measured muscle mass irrespective of age or weight(Ge riatr Gerontol Int. 2020).

It is advised to use calf circumference as a case finding i n the diagnosis of sarcopenia and as a marker for reduce d muscle mass.

The cutoff range however, varied by location and ethnic ity. There are no research

studies conducted among Indians but Asian cut-off range is considered in this application as one among four screening criteria . Hence a study conducted in Japan involved 1239 adults participated in this cross-sectional study on calf circumference as a marker for sarcopenia. The Global Leadership Initiative on Malnutrition (GLI

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M) has suggested that "cut off values for calf circumference in male < 33 cm and in female < 32 cm." These methods included both technical (bioelectrical impedance analysis, dual-energy x-ray absorptiometry, computerized tomography, and ultrasound) and clinical (calf circumference, midarm circumference, and physical examination) methods for diagnosing malnutrition (Barazzoni R ,2022).

Hence, the scoring for web application has been considered as <33cm for male as score 1 (as risk) & >or equal to 33cm is considered as score 0 . Similarly for women <32cm as score 1 (as risk) & >or equal to 32cm is considered as score 0 .

3. Physical activity level (active /moderate/poor) :

Exercise plays a crucial role in preserving muscle mass, particularly as individuals age or face health challenges. Regular physical activity not only enhances muscle strength but also mitigates the biological processes that lead to muscle atrophy.

There is mounting evidence that physical activity levels have a significant impact on the course of sarcopenia and muscle loss (Kortebein et al. 2008).The main causes of sarcopenia are

prolonged inactivity and sedentary behavior, which can increase the loss of muscle mass and strength, impede mobility, raise the risk of falls, and increase mortality (Montero-Fernandez and Serra-Rexach 2013).

Prevention of Muscle Atrophy: Engaging in consistent exercise can counteract the loss of muscle mass associated with aging and illness(Cartee, G. D,2017)(Shen et al., 2018).

Enhanced Mitochondrial Function: Exercise improves mitochondrial health, which is crucial for energy metabolism in muscle fiber (Shen et al., 2018).

Improved Mobility and Quality of Life: Maintaining muscle mass through exercise directly correlates with better mobility and reduced risk of chronic diseases(Donegà et al., 2024).

Conversely, while exercise is beneficial, excessive or unaccustomed physical activity can lead to muscle damage and soreness, potentially hindering muscle function temporarily(Shen et al., 2018). Even during severe calorie deprivation, lean mass is remarkably preserved when low-intensity exercises like walking or arm cranking are performed concurrently (Jose A. L. Calbet,2017).

Major muscle groups should be used in muscle-strengthening exercises at least twice a week.

When done for at least ten minutes, the following sports are listed by the Health Survey for England as muscle-strengthening activities: badminton, canoeing, climbing, cycling, dancing, field athletics, football, horseback riding, kayaking, rowing, rugby, running/jogging, sailing, squash, skiing/snowboarding, swimming, tai-chi, tennis, water-skiing, and windsurfing .Aqua aerobics/aquafit, aerobics, basketball, body boarding, bowls, exercise (press-ups, sit-ups, etc.), cricket, curling, golf, hillwalking, hockey, ice skating, martial arts other than tai chi, netball, pilates, rambling, surfing, tenpin bowling, volleyball, gym workouts (e.g., exercise bike, weight training), and yoga (when done for at least 10 minutes) are also included (Foster, Charlie,2018).

According to the World Health Organization's (WHO) exercise guidelines, persons between the ages of 18 and 64 should perform at least 150 minutes of moderate-intensity activity, 75 minutes of vigorous-intensity exercise, or a similar combination of the two each week. For additional health benefits, adults should increase their weekly moderate-intensity physical exercise to 300 minutes or more.

Table:1: Assessment of the positive impact of different types of sport, physical activity or exercise on muscle, bone and balance outcomes (adapted from Heinonen & Kujala, in Kokko et al 2011).

Type of Sport, Physical Activity or Exercise	Improvement in Muscle Function	Improvement in Bone Health
Running	×	××
Resistance Training	×××	×××
Aerobics, circuit training	×××	×××
Ball Games	××	×××
Racquet Sports	××	×××
Yoga,Tai,Chi	×	×

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Dance	×	××
Walking	×	×
Nordic Walking	××	NK
Cycling	×	×

××× Strong effect , ×× Medium effect , ×=low,0=no effect , NK = not known

Hence in the web based application the scoring is done based on the above criteria such as:

- **Sedentary lifestyle which does not involve any structured physical activity that is classified as poor with a scoring of '2'involving risk of muscle loss.**
- **Moderate intensity involving at least 150 minutes of cardio-respiratory activities , 75 minutes of vigorous-intensity exercise, or a similar combination of the two each week is scored as moderate which is classified as '1'.**
- **High intensity workout involving both resistance strength training for muscle and cardio-respiratory endurance activities as stated above can be considered as the most recommended and classified under score '0'.**

4. Intake of protein is used for scoring:

Recommended intake of protein among Indians, based on recent research and established guidelines by ICMR-NIN 2020 Expert Group adopted the FAO/WHO/UNU (2007) approaches to define protein requirements for different age groups in India. The Estimated Average Requirement (EAR) for healthy Indian adults is set at 0.66 g/kg/day, while the Recommended Dietary Allowance (RDA) is 0.83 g/kg/day for healthy individual for reference body weight for an adult Indian man is set at **65 kg and** adult woman, the reference body weight is **55 kg** which is a revision from the previous RDA of 1 g/kg/day established in 2010.

Experts have recommended for individuals consuming a cereal-based diet with low-quality protein, the paper notes that the protein requirement may be as high as 1 g/kg/day. This highlights the importance of protein quality in dietary planning.

Regardless of age, the current global Recommended Dietary Allowance (RDA) for protein is 0.8 g per kilogram of body weight (bw) . The Reference Nutrient Intake (RNI) in the United Kingdom is 0.75 g/kg/bw. Rather than being optimized for physical activity level (PAL), these recommendations are derived as a minimal amount to maintain nitrogen balance. Compared to individuals who are active, people with poor PAL have higher protein needs to maintain muscle tissue because they have lower rates of nitrogen retention (Marta Lonnie ,2018).

Among ageing population, their total physical function and quality of life depend on the health of their skeletal muscles, which is maintained in large part by protein. However it is important to consume enough protein to promote muscle remodelling and stop age-related muscle loss (Paul T. Morgan,2023).

Hence, in web based application we have considered less than or equal to 0.8g protein /kg body weight as a high score of '2' but optimal intake of protein between 0.9 to 1g protein/kg body weight remains as '0'. Higher than 1g of protein intake in adult population needs further evaluation from Clinical Dietitian hence, scored as '1'.

The overall Muscle Function Protein Score(MFPS) application is available online through link has been divided into seven different sections :

Section 1: Consisting of Personal information such as name ,contact number ,gender (all information is not saved in the domain).

Section 2: This includes basic anthropometric data such as Height in centimetre ,Weight in Kilogram , Body Mass Index(BMI) in Kg/m^2 , Ideal Body Weight / Adjusted Body Weight in Kilogram as mentioned below.

Section 3: Involves Strength assessment report as per the above cut-off values based on references available and quoted .

Fig 1: Muscle Function Protein Score , Personal information : Name,Contact number to identify, Gender. Body composition metrics ; Height (cm), Weight(kg) ,BMI kg/m^2(Body Mass Index), Ideal Body Weight/Adjusted Body Weight (IBW/ABW)in

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Kg. Strength & Physical test Report ; Hand Grip Strength (Normal/Weak) ,Calf circumference (cm), Physical Activity (Poor , Moderately active , Active).Hand Grip Strength : An average grip strength reference values used for scoring are 20 kg for women and 33 kg for males (Rajani P Mullerpatan , 2013). Normal hand grip is considered as 0 but weak grip strength as 1 as scoring system in application.

- **Calf circumference :** Scoring for web application has been considered as <33cm for male as score 1 (as risk) & >or equal to 33cm is considered as score 0 . Similarly for women <32cm as score 1 (as risk) & >or equal to 32cm is considered as score 0 .

- **Physical Activity Level:** Sedentary lifestyle which does not involve any structured physical activity that is classified as **'poor'** with a scoring of '2'involving risk of muscle loss.Moderate intensity involving at least 150 minutes of cardio-respiratory activities , 75 minutes of vigorous-intensity exercise, or a similar combination of the two each week is scored as '**moderate**' which is classified as '1' as '**active'**. High intensity workout involving both resistance strength training for muscle and cardio-respiratory endurance activities as stated above can be considered as the most recommended and classified under score'0'.

Section 4: This involves Nutrition Information which is the diet history such as:

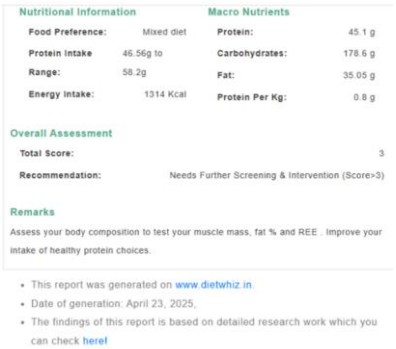

Fig 2:Nutritional Information,Macronutrients ,Overall Assessment ; Total score and recommendation with Remarks.

- Food preferences classified as mixed diet(non-vegetarian) , vegan, lacto-vegetarian (includes dairy only as animal source) and ovo-vegetarian(includes egg with dairy).
- Intake of recommended intake of protein range is provided from 0.8-1g per kg body weight (preferred body weight such as actual /current body weight or Ideal body weight / adjusted body weight based on body mass index (BMI) can be selected by user/ Clinical Dietitian .
- For ideal body weight (IBW) & adjusted body weight(ABW)Kg: md calc software calculation used as reference for formula (https://www.mdcalc.com/calc/68/ideal-body-weight-adjusted-body-weight#evidence) such as : In order to quickly determine the optimal body weight the Devine Formula was developed in 1974. In Devine formula height is used and most commonly applied method for both scholarly and medical purposes (M P Pai ,2000).

Devine formula below to calculate the ideal body weight:

Men: Ideal Body Weight (kg) = 50 kg + 2.3 kg per inch over 5 feet.

Women: Ideal Body Weight (kg) = 45.5 kg + 2.3 kg per inch over 5 feet.

For Adjusted Body Weight (ABW), for use in obese patients (where actual body weight > IBW): ABW = IBW + 0.4 x (actual body weight - IBW).

- **Section 5:** Intake of Macronutrients such as Energy , Protein ,Fat & Carbohydrate calculated based on Food Exchange List , input provided by the user as per ICMR guidelines 2011 & Diet Metrics,2018 for other miscellaneous values based on the 3 day dietary recall obtained from the client:

Table:2: Food Exchange List ; ICMR guidelines 2011 & Diet Metrics,2018

Food Group	g/portion(raw)	Energy(kcal)	Protein(g)	Carbohydrate(g)	Fat(g)
Cereals & Millets	30	100	3.0	20	0.8
Pulses-dhals/ bean	30	100	6.0	15	0.7
Egg	50	85	7.0	-	7.0

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Meat/ Chicken /Fish	50	100	9.0	-	7.0
Milk(ml)& Milk Products	100	70	3	5.0	3
Roots & Tubers	100	80	1.3	18	-
Green leafy vegetable	100	46	3.6	-	0.4
Other vegetable	100	28	1.7	-	0.2
Fruits	100	40	-	10	-
Sugar	5	20	-	10	-
Fats & Oils(visible)	5	45			5.0
Nuts (Diet Metrics,2018)	15g	85	3	2	7
Paneer (Nandhini)	50g	149	9	2.2	11.3
Tofu (Silken)	100g	70	7	2.2	1.4

- Intake of protein per kg body weight is also available in the final report.

Section 6: Overall total score is reflected in this section which is interpreted as 0-3. The lowest risk score is between 0-2 but the highest is 7 which is considered as high risk. The final score obtained between 0 to 2 may require re-screening after 12 weeks but the score equivalent to or more than 3 needs further attention from the Clinical Dietitian who can take a decision along with the treating Doctor to subject the patient to further comprehensive nutrition assessment.

Section 7: The user or Clinical Dietitian can update their remarks or any further recommendation s or plan of action for their patient/ client.

Fig 3:The generated report can be downloaded with date and reference link available for the user to access .

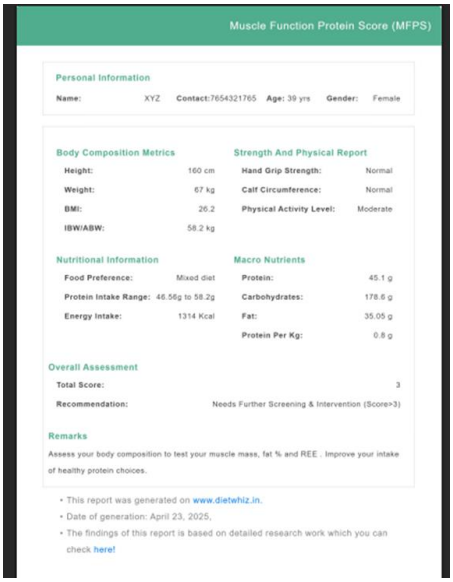

Fig 4:Glimpse of a completed report

The final report can be downloaded and further information on MFPS can be generated in PDF format, emailed or shared though what's app with date of generation & the research findings or interpretation can be accessed by the user as well as client in the same website(https://dietwhiz.in/)

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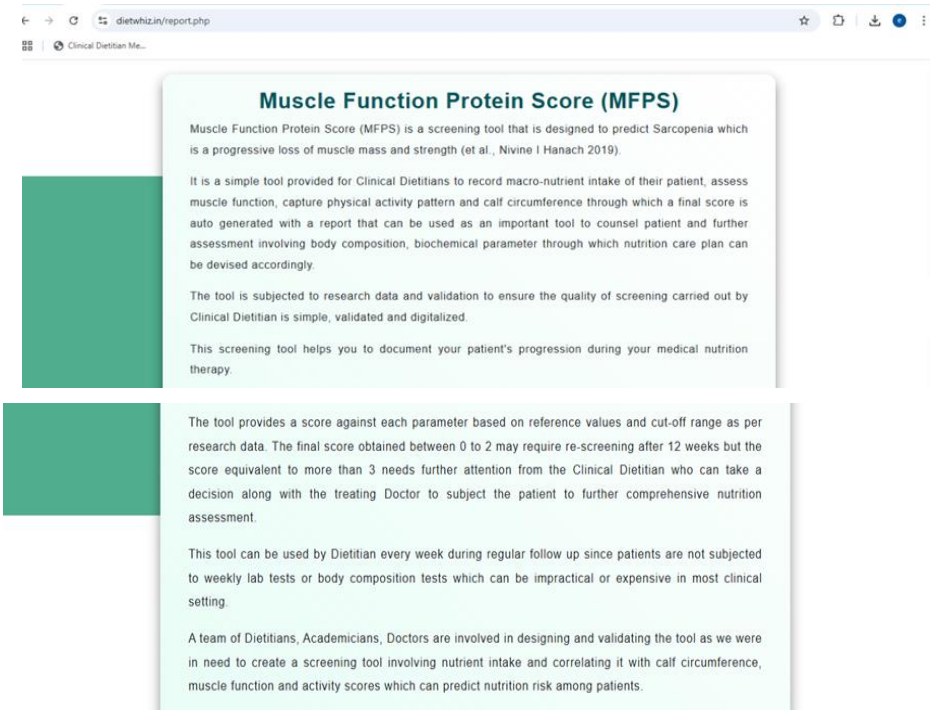

Fig 5 :Detailed information and interpretation of MFPS is provided to the user.

Fig 6 : Reference link and research data on criteria used for cut off range available for the user.

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Results :

Table 1

Characteristics	Statistical Summary	
Age (Years)	n	632
	Mean ± SD	37.77 ± 10.96
	Median (Q1, Q3)	37.5 (29.0, 46.0)
	Min, Max	18.0, 60
Gender		
Male	n (%)	270 (47.72)
Female	n (%)	362 (57.28)
Body Mass Index(kg/m^2)	n	632
	Mean ± SD	25.65 ± 4.50
	Median (Q1, Q3)	25.3 (22.7, 28.5)
	Min, Max	14.50, 42.30
Calf Circumference (cm)	n	632
	Mean ± SD	35.28 ± 3.71
	Median (Q1, Q3)	35.0 (33.0, 38.0)
	Min, Max	22.0, 54.0
Hand Grip Strength of Dominant Hand (kg)	n	632
	Mean ± SD	26.14 ± 9.28
	Median (Q1, Q3)	24.25 (19.40, 31.60)
	Min, Max	7.20, 55.80
Hand Grip Strength of Non-Dominant Hand (kg)	n	632
	Mean ± SD	25.19 ± 9.33
	Median (Q1, Q3)	23.0 (18.40, 30.60)
	Min, Max	8.20, 56.20

SD: Standard Deviation;

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Min: Minimum; Max: Maximum

Table 2:

Characteristics	Statistical Summary	
Eating Behaviour		
Lacto-Vegetarian	n (%)	224 (35.40)
Mixed Diet	n (%)	350 (55.40)
Ovo-Vegetarian	n (%)	58 (9.20)
Muscle Protein Score		
Not at Risk	n (%)	240 (39.70)
Risk	n (%)	364 (60.30)
Muscle Protein Score	n	604
	Mean ± SD	3.09 ± 1.67
	Median (Q1, Q3)	3.0 (2.0, 4.0)
	Min, Max	0.0, 7.0
Age Group (Years)		
18-30	n (%)	207 (32.80)
31-40	n (%)	172 (27.20)
41-50	n (%)	154 (24.40)
51-60	n (%)	99 (15.60)

SD: Standard Deviation;

Min: Minimum; Max: Maximum

Table 3 Distribution of characters by Muscle Protein Score

Characteristics	Statistical Summary	Muscle Protein Score		P-value
		Not at Risk	Risk	
Age (Years)	n	240	364	0.7096
	Mean ± SD	37.81 ± 10.80	38.15 ± 11.09	
Age group (Years)				
18-30	n (%)	77 (32.10)	116 (31.90)	0.9775
31-40	n (%)	67 (27.90)	97 (26.60)	

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41-50	n (%)	59 (24.60)	91 (25.00)	
51-60	n (%)	37 (15.40)	60 (16.50)	
Gender				
Male	n (%)	107 (44.60)	157 (43.10)	0.7251
Female	n (%)	133 (55.40)	207 (56.90)	
Body Mass Index(kg/m^2)	n	240	364	0.5930
	Mean ± SD	25.82 ± 4.37	25.62 ± 4.58	
Calf Circumference (cm)	n	240	364	0.1317
	Mean ± SD	35.58 ± 3.41	35.11 ± 3.95	
Hand Grip Strength of Dominant Hand (kg)	n	240	364	<0.0001
	Mean ± SD	30.24 ± 9.79	23.47 ± 7.95	

SD: Standard Deviation;

P-value for continuous variable obtained from independent sample t-test and for categorical variable chi-square test; P-value <0.05 is significant;

Table 4:

Characteristics	Statistical Summary	Muscle Protein Score		P-value
		Not at Risk	Risk	
Hand Grip Strength of Non-Dominant Hand (kg)	n	240	364	<0.0001
	Mean ± SD	29.56 ± 9.92	22.35 ± 7.79	
Eating Behaviour				
Lacto-Vegetarian	n (%)	79 (32.90)	136 (37.40)	0.2169
Mixed Diet	n (%)	142 (59.20)	190 (52.20)	
Ovo-Vegetarian	n (%)	19 (7.90)	38 (10.40)	

SD: Standard Deviation

P-value for continuous variable obtained from independent sample t-test and for categorical variable chi-square test; P-value <0.05 is significant;

The distribution of participant characteristics by Muscle Protein Score was analysed to identify potential associations with being at risk or not at risk. Among the 240 participants not at risk and 364 participants at risk, the mean age was similar between the two groups (37.81

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± 10.80 years vs. 38.15 ± 11.09 years), with no statistically significant difference (p = 0.7096). Age group distribution also showed no significant variation (p = 0.9775), with the 18–30 age group comprising 32.10% of the not-at-risk and 31.90% of the at-risk groups.

Gender distribution was relatively balanced, with 44.60% of males in the not-at-risk group and 43.10% in the at-risk group (p = 0.7251), indicating no significant gender difference. Body Mass Index (BMI) was also similar between groups (25.82 ± 4.37 kg/m² vs. 25.62 ± 4.58 kg/m², p = 0.5930), as was calf circumference (35.58 ± 3.41 cm vs. 35.11 ± 3.95 cm, p = 0.1317), neither of which showed significant associations with muscle protein risk.

However, hand grip strength was significantly different between groups. For the dominant hand, the not-at-risk group had a mean strength of 30.24 ± 9.79 kg compared to 23.47 ± 7.95 kg in the at-risk group (p < 0.0001). Similarly, for the non-dominant hand, the not-at-risk group had significantly higher strength (29.56 ± 9.92 kg vs. 22.35 ± 7.79 kg, p < 0.0001). These results suggest that hand grip strength is strongly associated with muscle protein status.

In terms of eating behaviour, although not statistically significant (p = 0.2169), a higher proportion of individuals in the at-risk group followed a lacto-vegetarian diet (37.40%) compared to the not-at-risk group (32.90%). Mixed diet consumption was more common in the not-at-risk group (59.20%) compared to the at-risk group (52.20%). Ovo-vegetarians constituted 7.90% of the not-at-risk group and 10.40% of the at-risk group.

Table 3 Correlation Table for Muscle Function Protein Score

Characteristics	Muscle Protein Score
Age (years)	
Correlation Coefficient |ρ|	-0.018
P-value	0.6569
Body Mass Index(kg/m^2)	
Correlation Coefficient |ρ|	-0.029
P-value	0.4839
Calf Circumference (cm)	
Correlation Coefficient |ρ|	-0.081
P-value	0.0480
Hand Grip Strength of Dominant Hand (kg)	
Correlation Coefficient |ρ|	-0.379
P-value	<0.0001
Hand Grip Strength of Non-Dominant Hand (kg)	
Correlation Coefficient |ρ|	-0.389
P-value	<0.0001

Correlation obtained from Karl Pearson's Coefficient of Correlation

Table 4: Internal Consistency Reliability Test

Number of Items	Cronbach's Alfa
3(calf circumference, HGS DH , NDH)	0.735
2(Hand grip strength DH, HGS NDH)	0.955

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The internal consistency reliability test for the Muscle Protein Score (MPS) components showed a Cronbach's Alpha of 0.735 when three items were included, indicating an acceptable level of internal consistency.

Discussion :

A total of 632 participants were included in the study. The mean age was 37.77 ± 10.96 years, with a median of 37.5 years (interquartile range [IQR]: 29.0–46.0), ranging from 18 to 60 years. Of the participants, 270 (47.72%) were male and 362 (57.28%) were female.

Table 1 depicts the average Body Mass Index (BMI) was 25.65 ± 4.50 kg/m², with a median of 25.3 kg/m² (IQR: 22.7–28.5), ranging from 14.50 to 42.30 kg/m². The average BMI was **25.65 kg/m²** with a standard deviation of **4.50 kg/m²**, placing the average participant in the **overweight** category based on WHO classification. The median BMI was **25.3 kg/m²** with an IQR of **22.7 to 28.5 kg/m²**, suggesting most participants were within the **normal to overweight** range. The BMI values ranged from **14.5 (underweight)** to **42.3 (obese)**, showing a broad distribution of body weight statuses.

Calf circumference had a mean of 35.28 ± 3.71 cm, median of 35.0 cm (IQR: 33.0–38.0), with values ranging between 22.0 and 54.0 cm.

Hand grip strength for the dominant hand averaged 26.14 ± 9.28 kg, with a median of 24.25 kg (IQR: 19.40–31.60), and ranged from 7.20 to 55.80 kg. For the non-dominant hand, the mean strength was 25.19 ± 9.33 kg, with a median of 23.0 kg (IQR: 18.40–30.60), ranging from 8.20 to 56.20 kg.

In terms of eating behaviour, 224 participants (35.40%) followed a lacto-vegetarian diet, 350 (55.40%) consumed a mixed diet, and 58 (9.20%) were ovo-vegetarian. The muscle function protein score indicated that 240 participants (39.70%) were not at risk, while 364 (60.30%) were at risk. The mean muscle function protein score among 604 participants was 3.09 ± 1.67, with a median of 3.0 (IQR: 2.0–4.0), ranging from 0.0 to 7.0.

Based on age distribution, 32.80% were aged 18–30 years, 27.20% were 31–40 years, 24.40% were 41–50 years, and 15.60% were in the 51–60 years age group.

The participants had a mean age of **37.77 years** with a standard deviation of **10.96 years**, indicating a relatively wide spread of ages. The median age was **37.5 years**, with an interquartile range (IQR) of **29.0 to 46.0 years**, suggesting that the central 50% of the participants were primarily within early to middle adulthood. The age ranged from **18 to 60 years**, indicating inclusion of both younger and older adults. The mean calf circumference was **35.28 cm**, and the median was **35.0 cm** (IQR: **33.0–38.0 cm**). This is a useful anthropometric measure often associated with muscle mass and nutritional status. The values ranged from **22.0 to 54.0 cm**, indicating variation in muscle bulk or adiposity among participants. Notably, grip strength was slightly higher in the dominant hand, which is consistent with expected physiological trends. The dataset represents a relatively young to middle-aged adult population, with a slightly higher number of females. The average BMI suggests an overweight population, with a wide distribution across weight categories. Muscle strength, as indicated by grip strength and calf circumference, also varies broadly, which could be relevant for evaluating functional status, nutritional status, or risk stratification in clinical or research settings.

Table 2 :

Over **half of the participants follow a mixed diet**, incorporating both plant- and animal-based foods. A significant **44.6% follow vegetarian diets** (lacto- and ovo-).A substantial **60.3% of participants are considered at risk** based on their muscle function protein score, suggesting **inadequate protein intake or compromised protein quality** relative to needs for muscle maintenance or function. The **average score of 3.09** on a 0–7 scale indicates a **moderately low protein status** across the cohort. The median value of **3.0** and an IQR of **2.0–4.0** reinforce that **most participants cluster around low-to-mid protein adequacy**, with very few scoring at the upper end. These findings **align with the high proportion of vegetarian dietary practices**, raising concerns about protein sufficiency in this population, particularly in muscle-related health outcomes.

The population skews **younger**, with more than **60% under age 40**. This is a critical period for **optimizing muscle mass and metabolic health**, meaning the high prevalence of muscle protein risk in these age groups could have **long-term implications** if not addressed early. The relatively smaller proportion in older age groups might underrepresent age-related declines in muscle mass (sarcopenia), but the current findings still underscore the **need for early dietary and lifestyle interventions**.

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Assessing the relationship between various physical parameters and the Muscle Function Protein Score :

Table 3 involves correlation analysis using Karl Pearson's Coefficient of Correlation was conducted to assess the relationship between various physical parameters and the Muscle Function Protein Score. The findings indicate that age had a negligible and non-significant negative correlation with muscle protein score ($r = -0.018$, $p = 0.6569$). Similarly, Body Mass Index (BMI) also showed a weak, non-significant negative correlation ($r = -0.029$, $p = 0.4839$).

Calf circumference demonstrated a weak but statistically significant negative correlation with the muscle protein score ($r = -0.081$, $p = 0.0480$), suggesting a slight inverse relationship.

In contrast, hand grip strength of both the dominant and non-dominant hands showed moderate negative correlations with the muscle protein score, which were highly significant. Specifically, dominant hand grip strength had a correlation coefficient of $r = -0.379$ ($p < 0.0001$), and non-dominant hand grip strength had $r = -0.389$ ($p < 0.0001$). These results suggest that as hand grip strength decreases, the risk indicated by the muscle protein score increases, and this association is stronger than for any of the other variables examined.

Reliability test for Muscle Function Protein Score (MFPS) :

This suggests that the three components used in this version of the score are reasonably consistent in measuring the same underlying construct, likely reflecting muscle protein status. In contrast, when only two items were used, the Cronbach's Alpha increased significantly to 0.955, which indicates excellent internal consistency. However, such a high value may also suggest redundancy between the two items, implying they might be capturing very similar information. Overall, the three-item version demonstrates a more balanced and reliable structure, while the two-item version, although highly consistent, may benefit from further evaluation to ensure it adds distinct value to the overall assessment.

Overall, hand grip strength of both hands showed a statistically significant association with muscle protein risk, while other variables such as age, BMI, calf circumference, gender, and dietary habits did not show significant differences between the groups.

These results highlight a **potential public health concern** and point to the **need for targeted nutritional education** focused on **quality protein intake** to reduce future risk of sarcopenia or related metabolic issues.

Conclusion

Muscle Function Protein Score is a predictor of sarcopenia and the web-based application was statistically tested to ensure the reliability using cronbach's alpha increased significantly to 0.955 indicating excellent internal consistency while tested on 604 participants and the results revealed that as hand grip strength decreases, the risk indicated by the muscle function protein score increases while this association is stronger than for any of the other variables examined. Hand grip strength of both the hands showed a statistically significant association with muscle protein risk. The application is safe, and the domain does not save any data or input provided by the user hence this application safeguards the data privacy of both user and client.The results also projects that the developed web based application can be used to generate the risk score for loss of muscle function correlating with intake of protein and physical activity that provides a report for a practising Dietitian to counsel patient's using a digital report that paves the way for further plan of care to recommend any further tests such as body composition analysis or laboratory tests to device a comprehensive nutrition care plan.

Commented [DB1]: Rewrite with clarity

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