Supplementary Table S1. Expanded evidence summary for age-specific protein and leucine recommendations

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Introductory note
This table compiles the mechanistic and clinical evidence underpinning the quantitative recommendations summarized in Tables 1 and 2. Data were drawn from stable-isotope tracer and dose–response studies of muscle protein synthesis (MPS), meta-analyses of resistance-training outcomes, and international consensus statements (ESPEN/PROT-AGE). Each statement corresponds to empirically supported protein or leucine thresholds, exercise guidance, or clinical practice recommendations relevant to a specific age or physiological phenotype.

Group	Statement	Evidence / Supporting References
1. Young adults (≤ 39 yr)	Daily protein 1.0–1.2 $g \cdot kg^{-1} \cdot day^{-1}$ for health; ≈ 1.6 $g \cdot kg^{-1} \cdot day^{-1}$ for hypertrophy	Meta-analysis of resistance-training trials shows fat-free-mass gains plateau at ≈ 1.6 $g \cdot kg^{-1} \cdot day^{-1}$ for resistance-trained subjects (Morton et al., 2018).
	20–25 g high-quality protein (~2 g Leu) maximizes MPS	Dose–response studies in young, resistance-trained men show 20 g whey (~2 g Leu) elicits maximal post-absorptive MPS; 40 g does not further increase MPS but raises oxidation and urea (Moore et al., 2009; Witard et al., 2014).
	≥ 3 resistance sessions / wk, progressive overload	Consensus guidelines recommend 3–5 weekly sessions with progressive overload for hypertrophy (Morton et al., 2018).
	Leucine "extra" unnecessary once 20 g threshold is met	The "muscle-full" effect explains why additional leucine above ~2 g per meal does not further stimulate MPS in young adults (Atherton et al., 2010).
2. Midlife adults (40–59 yr)	Daily protein 1.2–1.4 $g \cdot kg^{-1} \cdot day^{-1}$	ESPEN/PROT-AGE raise lower bounds to 1.0–1.2 $g \cdot kg^{-1} \cdot day^{-1}$ for healthy older adults; 1.2–1.4 $g \cdot kg^{-1} \cdot day^{-1}$ reflects early onset of anabolic resistance (Deutz et al., 2014; Bauer et al., 2013).
	25–30 g protein (~2.2–2.5 g Leu) per meal	Interpolated between 20 g young breakpoint and ~30 g older breakpoint (~0.4 $g \cdot kg^{-1}$ per meal) (Zaromskyte et al., 2021).
	≥ 2 resistance sessions / wk + ≥ 7,000 steps/day	Physical-activity levels associated with reduced anabolic resistance are cited in muscle-aging reviews (Breen et al., 2011; Wall et al., 2015).
	Even protein distribution (≥ 3 meals/day)	Balanced protein distribution (~30 g per meal) increases 24-h MPS compared with skewed patterns (Areta et al., 2013).
3. Older adults (≈ 60–70 yr)	Daily protein 1.2–1.6 $g \cdot kg^{-1} \cdot day^{-1}$	PROT-AGE and ESPEN recommend 1.0–1.2 $g \cdot kg^{-1} \cdot day^{-1}$ (healthy), 1.2–1.5 $g \cdot kg^{-1} \cdot day^{-1}$

Group	Statement	Evidence / Supporting References
		(disease/injury), up to ~2.0 g·kg^{-1}·day^{-1} (severe illness) (Bauer et al., 2013; Deutz et al., 2014).
	30–40 g protein (~2.8–3 g Leu) per meal	Per-meal breakpoint ≈ 0.4 g·kg^{-1} (~30–35 g protein); leucine ~2.8 g restores MPS to young levels (Katsanos et al., 2006; Moore et al., 2015).
	≥ 2–3 resistance sessions / wk + balance & mobility work	Studies show 2–3 sessions weekly improve MPS and strength (Breen et al., 2011; Wall et al., 2015).
	Leucine-rich sources & carbohydrate (CHO) co-ingestion	Whey, dairy, or eggs yield higher leucinemia; carbohydrate enhances insulin-mediated muscle perfusion (Gorissen et al., 2020; Burd et al., 2011).
4. Frail / sarcopenic or clinical adults (≥ 75 yr)	Daily protein 1.4–2.0 g·kg^{-1}·day^{-1} (†)	ESPEN/PROT-AGE upper end for illness, malnutrition, or injury (Bauer et al., 2013; Deutz et al., 2014).
	25–30 g protein (~3 g Leu) in small, frequent meals	Leucine-enriched meals (~3 g Leu) stimulate MPS comparably to larger boluses in older adults (Rieu et al., 2006; Katsanos et al., 2006).
	Light resistance or NMES if immobile	Neuromuscular electrical stimulation (NMES) induces anabolic signaling in bedridden elders (Dirks et al., 2015).
	Leucine-enriched whey/EAA blends; monitor renal function	Clinical guidance recommends renal monitoring when protein > 1.8 g·kg^{-1}·day^{-1} (Bauer et al., 2013).
5. Rehabilitation / illness (catabolic states)	Daily protein 1.5–2.0 g·kg^{-1}·day^{-1} (†)	Same upper-end guidance for catabolic /post-operative patients (Deutz et al., 2014; Bauer et al., 2013).
	30–40 g protein (~3 g Leu) post-therapy	Post-exercise studies show 40 g whey > 20 g in stimulating MPS post-exercise (Yang et al., 2012).
	Protein timed around physiotherapy	Protein within 1 h of therapy enhances nutrition–training synergy (Areta et al., 2013; Burd et al., 2011).
	Add omega-3, vitamin D, adequate energy	Omega-3 and vitamin D augment MPS in older adults (Smith et al., 2011; Phillips et al., 2020).

General notes

† Protein intakes ≥ 1.8–2.0 g·kg^{-1}·day^{-1} should only be used under medical supervision and with adequate renal function. This expanded evidence summary directly supports the age- and phenotype-specific recommendations presented in Tables 1 and 2 of the main manuscript.

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