Add Health
The National Longitudinal Study of Adolescent to Adult Health

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Physical Function User Guide

Add CAPS
Add Health Cognitive Assesment, Physical, and Sensory Function

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1. Introduction

The National Longitudinal Study of Adolescent to Adult Health (Add Health) is a nationally representative sample of U.S. adolescents who were in grades 7-12 during the 1994-1995 school year. Using a complex, school-based cluster-sampling frame, researchers selected high school and feeder school pairs from 80 communities across the United States and drew a sex- and grade-stratified random sample of 20,745 adolescents for inclusion in the study. This sample has been followed from adolescence into early midlife across six waves of data collection to date, with the most recent wave of data collection (Wave VI) taking place between 2022 and 2025 when participants were ages 39 to 51, with an average age of 44.

Over the years, Add Health has collected a wealth of information from participants and their parents about demographic characteristics, familial structures, social relationships, health behaviors, cognition, physical and mental health status, medication usage, and health care access. Add Health also has collected anthropometric, cardiovascular, metabolic, renal, hepatic, inflammatory/immune, infectious, neurodegenerative, and multi-omic biomarkers from participants. In addition, Add Health has merged multilevel contextual data about the economic, school, neighborhood, policy, and environmental contexts in which the participants are embedded to the core survey and biological data at each wave. The Add Health dataset thereby provides researchers with rich opportunities to explore the causes and consequences of health status across multiple contextual domains as individuals age across the life course.

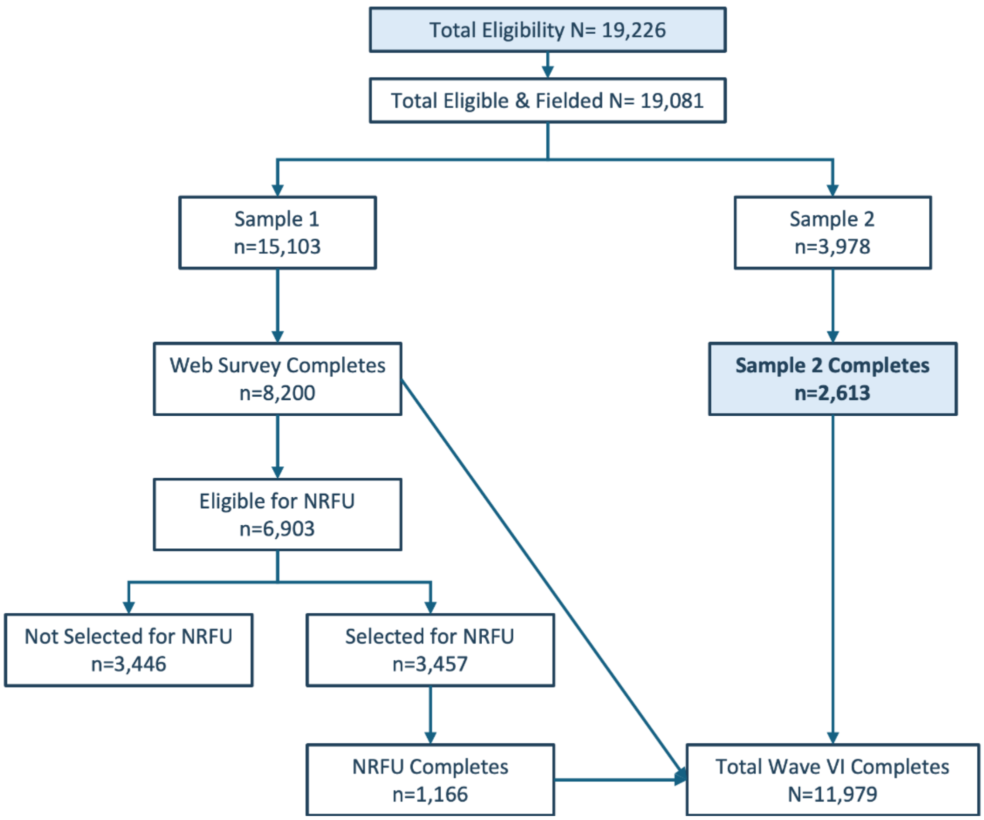
A central goal of Wave VI was to expand measurement in the cognitive, physical, and sensory domains at early midlife. To support this, Add Health introduced the Cognitive, Physical, and Sensory Function (Add CAPS) battery, designed for long-term tracking across these domains. Given its breadth of measures and longitudinal design, Add Health provides a unique opportunity to examine early midlife physical function. At Wave VI, this included a new measure of handgrip strength in Sample 2 and several physical function survey questions in Samples 1 and 2, allowing researchers to track how these measures relate to health, cognitive function, and longevity in a nationally representative cohort followed since adolescence. The full list of Add CAPS assessments can be found in **Table 1.**

Add CAPS User Guide	Add CAPS Data Set	Add CAPS Assessment	Cognitive Domain Measured
TestMyBrain	accb1_6.sas7bdat	Verbal Paired Associates	Episodic Memory
		Digit Symbol Matching	Processing Speed
		Gradual Onset Continuous Performance Test	Executive Functioning
		Backward Digit Span	Working Memory
NIH Toolbox Cognition	accb3_6.sas7bdat	Dimensional Change Card Sort Test	Executive Functioning
		Pattern Comparison Processing Speed Test	Processing Speed
		Picture Vocabulary Test	Language/Semantic Fluency
Interviewer-Administered Word Recall and Backward Digit Span	accb2_6.sas7bdat	Immediate Word Recall	Episodic Memory
		Delayed Word Recall	Episodic Memory
		Backward Digit Span	Working Memory
Animal Naming Test	acaf_6.sas7bdat	Animal Naming Test	Language/Semantic Fluency
Sensory Function	acsb_6.sas7bdat	hearX hearTest	
Physical Function	acpb_6.sas7bdat	Handgrip Strength	

Table 1. Wave VI Add CAPS assessments and corresponding datasets and User Guides.

Add Health Wave VI was divided into two nationally representative subsamples: Sample 1 and Sample 2 (as detailed in the Sampling and Mixed-Mode Survey Design User Guide; see Hummer et al. 2025). The breakdown of Wave VI sample assignments can be seen in **Figure 1.** Sample 1 members received a primarily web-based, two-phase mixed-mode design, which included web-based cognitive assessments (see the TestMyBrain User Guide (Aiello et al. 2025)). Sample 2 members (N=2,613) received an in-person interview which included the Sample 1 survey content plus in-person cognitive, physical, and sensory functioning assessments (the remaining Add CAPS assessments). At the end of Sample 2 data collection, a small number of Sample 2 members who could not schedule an in-person interview were permitted to complete the web survey and thus did not receive the in-person Add CAPS assessments (N=70).

Figure 1: Overview of Wave VI Sample Design and Completes



Handgrip strength assessments were conducted only among Sample 2 participants (N=2,613). Data included in the Physical Function dataset can be linked to the full survey data with the Sample 2 Mixed-Mode Survey data file (w6s2.sas7bdat), described in the Wave VI Sampling and Mixed-Mode Survey User Guide (Hummer et al. 2025) and the Wave VI Sample 2: Mixed-Mode Survey Codebook (https://addhealth.cpc.unc.edu/wp-content/uploads/docs/restricted_use/WaveVISample2MixedModeSurveyCodebook.pdf). For cross-sectional estimations of the Add CAPS assessments in Sample 2, including the handgrip strength assessments, optimized Sample 2 weights have been created (variable GSW6_2) and should be used in all corresponding analyses. For further details on the weighting methodology and usage recommendations, please see the Guide to Using Cross-Sectional and Longitudinal Weights in Add Health Wave VI (see Liao et al. 2025).

The Add CAPS physical function data establish a foundation for identifying early signs of midlife impairments that may help predict future risk of Alzheimer's disease and related dementias (AD/ADRD) as well as disability, mortality, and other aging-related outcomes.

2. General Overview of Handgrip Strength

Handgrip strength measures upper extremity muscle strength and reflects the overall state of muscle strength and physical function. This measure is particularly important in aging research, as prior studies have shown that lower grip strength is associated with functional limitations (Rantanen et al., 1999), cognitive decline (Hooghiemstra et al., 2017), dementia risk (Esteban-Cornejo et al., 2022), inflammation (Smith et al., 2019), and mortality (Malhotra et al., 2020). Additionally, grip strength serves as a key component of the Fried frailty Phenotype (Fried, 2021; Reeve et al., 2018) and sarcopenic obesity (Donini et al, 2022; Batsis & Villareal, 2018; Hamer & O'Donovan, 2017).

3. Hand Dominance

4. Rationale

Handgrip strength is a useful indicator of overall muscle strength and physical function, making it an informative proxy for age-related functional decline. Since the dominant hand is usually stronger than the non-dominant hand, hand dominance is an important factor to consider when interpreting grip strength results. Without accounting for dominance, a lower value from the non-dominant hand might be mistakenly viewed as weakness. Assessment reports typically provide multiple and separate values for each hand, which can then be compared with published reference standards to identify potential deficits. Determining hand dominance also helps address possible asymmetry between right- and left-handed individuals.

4.1 Measurement and Protocol

Participants were asked the following preliminary question before measuring grip strength: "For this first test, I need to know, are you left-handed or right-handed?" The response options were as follows:

1. LEFT-HANDED
2. RIGHT-HANDED

The response to this question determined the order in which grip strength was measured for each hand. A participant's dominant hand was measured first in all cases.

4.2 Variable Construction

3.3.1 Hand Dominance [H6PB1]

Interviewers asked whether participants were left-handed or right-handed. Their answers were constructed as the H6PB1 variable, with a value of 1 assigned to left-handed and 2 to right-handed.

5. Handgrip Strength

5.1 Rationale

Handgrip strength is a reflection of the overall state of muscle strength and physical function, thereby serving as a practical indicator of age-related functional decline. This measure is important among Add Health Wave VI participants as there is considerable variability in muscle strength and physical function in midlife, where maximal strength plateaus, and thereby serves as a baseline for the age-related declines observed in later years.

5.2 Measurement and Protocol

Handgrip strength was measured as part of the Wave VI Add Health Add CAPS battery using a handgrip dynamometer. In the home examination, trained examiners used a Jamar® Plus+ Digital Hand Dynamometer (Patterson Medical, Chicago, IL), to assess participants' maximal isometric grip force (specifications below).

The participant was instructed to squeeze as hard as possible for a few seconds. Measurements were taken with the participant seated, feet flat on the floor, elbow at a 90° angle, and arm close to but not touching the body. Each participant performed one practice trial on each hand, followed by two test trials for each hand, alternating between hands to prevent fatigue.

Examiners verbally encouraged the participants during each trial to ensure maximal effort. The digital dynamometer automatically displayed the force of each squeeze, and the examiner recorded the value immediately after each trial. If a participant's two trials on the same hand differed by more than a predetermined threshold (e.g. >30% difference), examiners were prompted to verify the readings.

5.3 Equipment

Interviewers used Jamar® Plus+ Digital Hand Dynamometer to measure handgrip strength.

Figure 2. Jamar® Plus+ Digital Hand Dynamometer.

Specifications:

- Measures and displays isometric grip force from 0 – 200 pounds (lbs) or 0 – 90 kilograms (kg).
- Electronic load cell technology delivers more accurate measurements than hydraulic components.
- Up to 5 tests per trial can be conducted with each hand without reset.
- Average, standard deviation, and coefficient of variation are automatically calculated.

For Wave VI of Add Health, the peak force reading was recorded for each trial in pounds (lbs).

5.4 Variable Construction

The participants' handgrip strength was measured through one practice and two main test trials for each hand, alternating hands in each round. Data was recorded only for the two main tests (trials 1 and 2 on dominant hand and trials 1 and 2 on non-dominant hand). Four variables were constructed as follows:

5.4.1 Handgrip Strength Hand 1 Trial 1 [H6PB11]

The peak force recorded (lbs) for the participant's first trial of their dominant hand.

5.4.2 Handgrip Strength Hand 1 Trial 2 [H6PB21]

The peak force recorded (lbs) for the participant's second trial of their dominant hand.

5.4.3 Handgrip Strength Hand 2 Trial 1 [H6PB12]
The peak force recorded (lbs) for the participant's first trial of their non-dominant hand.

5.4.4 Handgrip Strength Hand 2 Trial 2 [H6PB22]
The peak force recorded (lbs) for the participant's second trial of their non-dominant hand.

5.4.5 Duration [C6PBTS]
The length (in seconds) of the handgrip strength assessment, including setup and measurement.

5.4.6 Handgrip Strength Flag 1 [C6PBQ1 (dominant hand), C6PBQ2 (non-dominant hand)]
A flag indicating that the measured handgrip strength for at least one of the participant's trials was outside the expected range for their sex.

5.4.7 Handgrip Strength Flag 2 [C6PBQ3 (dominant hand), C6PBQ4 (non-dominant hand)]
A flag indicating a >30% difference in handgrip strength between two trials in the same hand.

5.4.8 Time Flag 1 [C6PBTF]
Flag assigned if test was an unexpectedly long or short duration

5.4.9 Time Flag 2 [H6PBTx]
Flag assigned if duration is unexpectedly long or short for one of the following reasons:

- Technical difficulties [H6PBT1]
- Participant took a break [H6PBT2]
- Interruption [H6PBT3]
- Did not complete test [H6PBT4]
- Did not understand instructions [H6PBT5]
- Physical or cognitive disability [H6PBT6]
- Other [H6PBT7]
- Refused to participate [H6PBT8]

5.5 Quality Control
The units of all dynamometers were set to pounds (lbs) before going into the field. Within-interview data entry checks were implemented in the Blaise survey platform preventing values below zero and greater than 999 from being entered (i.e. one could not progress in the survey if values outside this range were entered). Furthermore, if (a) values below 10 lbs. or greater than 150 lbs. for females and below 20 lbs. or greater than 200 lbs. for males or (b) two trials on the same hand differing by more than >30% prompted, a message appeared on the survey screen asking the interviewer to confirm the value.

Post-collection quality controls for handgrip strength were performed in two steps. First, we reviewed comments that interviewers noted when they observed any errors or remarks related to the test. Second, because of sex differences in handgrip strength values, we created sex-specific flag variables for each participant, based on a combination of published normative ranges (Wang, 2018) and expert-recommended ranges and acceptable inter-trial and inter-hand differences in strength. For both dominant and non-dominant hands, male participants reporting under 20 lbs. or over 200 lbs. were flagged, whereas female participants reporting under 10 lbs. or over 150 lbs. were also flagged. These ranges were based on the normative ranges published in Wang et al., 2018 but expanded to be much wider due to the small sample size in this paper and based on consultation with experts in the field. Additionally, if the difference between the first trial and the second trial exceeded 30%, it was flagged for further review. Flagged cases and cases with missing handgrip strength values were reviewed for interviewer comments and data validity.

0.4% of cases were flagged for out-of-expected range values and 3.0% of cases were flagged if they had a >30% difference between trials of the same hand. All cases with non-missing scores were determined to have valid handgrip strength measurements.

6. Survey Physical Function

Subjective reports of physical functioning and activity were asked of both Sample 1 and Sample 2 participants as part of the main Add Health Wave VI survey. Participants are asked to report if they have any difficulty participating in certain activities (e.g. running or jogging a mile, walking one block, climbing a flight of stairs, stooping or kneeling, etc.) due to a health problem. These data can be found in Section 4 of the mixed-mode survey data files (wave6.sas7bdat), variables H6ID5A, H6ID5B, H6ID5C, H6ID5D, H6ID5E, H6ID5F, H6ID6A, H6ID6B, H6ID6C, H6ID6D, H6ID6E, and H6ID6F. These variables were adapted from similar measures in the Health and Retirement Study (HRS, 2020).

7. The Physical Function Data File (acpb_6.sas7bdat)

7.1 Structure

The structure of the disseminated Physical Function data file is flat. This means that it is a participant-level data file, wherein each participant has one and only one record. The participant identifier (AID) appears in the data file only once.

7.2 Contents

Variable Name	**Variable Description**
AID	Participant Identifier
C6PBF1	Flag indicating that there was a distraction or interruption
C6PBF2	Flag indicating that there were interviewer capture issues
C6PBF3	Flag indicating that there were technical issues
C6PBF4	Flag indicating that participant had physical impairment or pain
C6PBF5	Flag indicating issues with administration or instruction
C6PBF6	Flag indicating low effort or fatigue

C6PBQ1	Flag indicating that the measured handgrip strength (dominant hand) for at least one trial was outside the expected range for their sex
C6PBQ2	Flag indicating that the measured handgrip strength (non-dominant hand) for at least one trial was outside the expected range for their sex
C6PBQ3	Flag indicating that there was >30% difference between trials for the dominant hand
C6PBQ4	Flag indicating that there was >30% difference between trials for the non-dominant hand
C6PBTF	Was the test duration as expected, shorter than expected, or longer than expected
C6PBTS	Handgrip strength test duration (seconds)
H6PB1	Variable indicating whether participant is left-handed (1) or right-handed (2)
H6PB01	Completed practice test for dominant hand
H6PB02	Completed practice test for non-dominant hand
H6PB11	Peak force (lbs) for first trial of dominant hand
H6PB12	Peak force (lbs) for first trial of non-dominant hand
H6PB21	Peak force (lbs) for second trial of dominant hand
H6PB22	Peak force (lbs) for second trial of non-dominant hand
H6PBT1	Flag indicating reason for unexpectedly long/short duration: technical difficulties
H6PBT2	Flag indicating reason for unexpectedly long/short duration: participant took a break
H6PBT3	Flag indicating reason for unexpectedly long/short duration: interruption during testing
H6PBT4	Flag indicating reason for unexpectedly long/short duration: participant did not complete all tests
H6PBT5	Flag indicating reason for unexpectedly long/short duration: participant did not understand instructions
H6PBT6	Flag indicating reason for unexpectedly long/short duration: participant had physical / cognitive disability
H6PBT7	Flag indicating reason for unexpectedly long/short duration: some other reason
H6PBT8	Flag indicating reason for unexpectedly long/short duration: participant refused to participate

8. References

Batsis J.A., & Villareal D.T. (2018). Sarcopenic obesity in older adults: aetiology, epidemiology and treatment strategies. *Nature Reviews: Endocrinology*, 14(9):513-537. doi:10.1038/s41574-018-0062-9

Donini L.M., Busetto L., Bischoff S.C., Cederholm T., Ballesteros-Pomar M.D., Batsis J.A., Bauer J.M., Boirie Y., Cruz-Jentoft A.J., Dicker D., Frara S., Frühbeck G., Genton L., Gepner Y., Giustina A., Gonzalez M.C., Han H.S., Heymsfield S.B., Higashiguchi T., Laviano A., Lenzi A., Nyulasi I., Parrinello E., Poggiogalle E., Prado .CM., Salvador J., Rolland Y., Santini F., Serlie M.J., Shi H., Sieber C.C., Siervo M., Vettor R., Villareal D.T., Volkert D., Yu J., Zamboni M., Barazzoni R. (2022). Definition and diagnostic criteria for sarcopenic obesity: ESPEN and EASO consensus statement. *Clinical Nutrition,* 41(4):990-1000. doi:10.1016/j.clnu.2021.11.014

Esteban-Cornejo, I., Ho, F. K., Petermann-Rocha, F., Lyall, D. M., Martinez-Gomez, D., Cabanas-Sánchez, V., Ortega, F. B., Hillman, C. H., Gill, J. M. R., Quinn, T. J., Sattar, N., Pell, J. P., Gray, S. R., & Celis-Morales, C. (2022). Handgrip strength and all-cause dementia incidence and mortality: findings from the UK Biobank prospective cohort study. *Journal of Cachexia, Sarcopenia and Muscle*, *13*(3). doi:10.1002/jcsm.12857

Fried, L. P., Cohen, A. A., Xue, Q. L., Walston, J., Bandeen-Roche, K., & Varadhan, R. (2021). The physical frailty syndrome as a transition from homeostatic symphony to cacophony. *Nature aging*, 1(1), 36-46. doi:10.1038/s43587-020-00017-z

Hamer, M., & O'Donovan, G. (2017). Sarcopenic obesity, weight loss, and mortality: The English Longitudinal Study of Ageing. *American Journal of Clinical Nutrition*, *106*(1). doi:10.3945/ajcn.117.152488

Hooghiemstra, A. M., Ramakers, I. H. G. B., Sistermans, N., Pijnenburg, Y. A. L., Aalten, P., Hamel, R. E. G., Melis, R. J. F., Verhey, F. R. J., Olde Rikkert, M. G. M., Scheltens, P., & van der Flier, W. M. (2017). Gait Speed and Grip Strength Reflect Cognitive Impairment and Are Modestly Related to Incident Cognitive Decline in Memory Clinic Patients With Subjective Cognitive Decline and Mild Cognitive Impairment: Findings From the 4C Study. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, *72*(6). doi:10.1093/GERONA/GLX003

Hummer RA, Dean SC, Liao D, Cooney D, Jackson C, Griffiths A, Aiello AE. 2025. Add Health Wave VI Documentation: Wave VI Sampling and Mixed-Mode Survey Design. Chapel Hill, NC: Carolina Population Center, University of North Carolina at Chapel Hill. doi:10.17615/ydjb-4305

HRS 2020 Final Release Codebook, Section G: Functional Limitations and Helpers. Health and Retirement Study. Accessed September 8, 2025. https://hrs.isr.umich.edu/sites/default/files/meta/2020/core/codebook/h20_00.html

Malhotra, R., Tareque, M. I., Tan, N. C., & Ma, S. (2020). Association of baseline hand grip strength and annual change in hand grip strength with mortality among older people. *Archives of Gerontology and Geriatrics*, *86*. doi:10.1016/j.archger.2019.103961

Rantanen, T., Guralnik, J. M., Foley, D., Masaki, K., Leveille, S., Curb, J. D., & White, L. (1999). Midlife hand grip strength as a predictor of old age disability. *JAMA*, *281*(6). doi:10.1001/jama.281.6.558

Reeve, T. E., Ur, R., Craven, T. E., Kaan, J. H., Goldman, M. P., Edwards, M. S., Hurie, J. B., Velazquez-Ramirez, G., & Corriere, M. A. (2018). Grip strength measurement for frailty assessment in patients with vascular disease and associations with comorbidity, cardiac risk, and sarcopenia. *Journal of Vascular Surgery*, *67*(5). doi:10.1016/j.jvs.2017.08.078

Smith, L., Yang, L., & Hamer, M. (2019). Handgrip strength, inflammatory markers, and mortality. *Scandinavian Journal of Medicine and Science in Sports*, *29*(8). doi:10.1111/sms.13433

Wang, Y. C., Bohannon, R. W., Li, X., Sindhu, B., & Kapellusch, J. (2018). Hand-grip strength: normative reference values and equations for individuals 18 to 85 years of age residing in the United States. Journal of Orthopaedic & Sports Physical Therapy, 48(9), 685-693. doi:10.2519/jospt.2018.7851