Normative Sway Balance and Cognitive Assessment Data

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ABSTRACT

Objective: Balance and cognitive function are impacted by normal development, aging, and clinical conditions such as concussion. Sway Medical, Inc. has developed mobile and smart device balance and cognitive tests that assess postural sway, simple reaction time, impulse control, inspection time, and memory. The purpose of the current study was to establish normative Sway Balance and Cognitive assessment data for males and females of expanded age ranges. **Participants**: Participants were between 44,836 to 165,492 individual users between nine and 80 years of age who completed a Sway baseline testing battery protocol, where one familiarization and two to three baseline tests are performed. **Results**: Statistically significant differences were found between male and female Sway Balance and Reaction Time scores/values at baseline (Balance, M - 78.8 ± 15.0, F - 84.4 ± 13.0 [p<.005]; Reaction Time, M – 254.8 ± 73.2, F – 275.5 ± 79.9 [p<.005]). Statistical comparison of Sway Balance baseline scores between the ages of 9 and 70 y.o. for both males and females reveal distinct statistically significant trends (e.g. Males: 9 vs. 10 y.o., p<.005; 10 vs. 11 y.o., p<.005). Similar statistically significant normative trends are observed for Sway Cognitive tests. **Conclusions**: Normative values for Sway Balance and Cognitive tests have presently been established and expanded beyond previously defined male and female age ranges and, consequently, should support the management of clinical conditions for broader populations.

Keywords: balance assessment, cognitive assessment, normative data

INTRODUCTION

Periodic monitoring of postural stability and cognitive function are important in understanding long-term balance and cognitive trajectories associated with normal development (Tomkinson, et al., 2018; Campbell, et al., 2008), normal aging (Karra, et al., 2017;), clinical disease progression (Lin, et al., 2013; Chen, et al., 2017), and acute injury (Ozinga, et al., 2018). Additionally, postural stability and neurocognitive functional assessments following acute injury are critical when assessing and managing acute clinical events and subsequent recovery (Purcell, 2014; Guskiewicz, 2011). In both instances, robust and reliable normative test data are needed for clinical interpretation of assessment results when individual baseline test scores are unavailable.

Sway's patented balance assessment is a substantial improvement over current clinical assessments that require large stationary in-clinic equipment to measure an individual's postural stability (Burghart, et al., 2017). Sway's balance assessment requires no more than the mobile device that a user already owns. Consequently, the Sway balance test is an accessible and objective way of assessing balance for at-home and in-clinic users (Dabbs, et al., 2017).

Similarly, Sway's proprietary motion-based assessments provide a much-needed alternative to cognitive testing devices requiring touch screen measurements (Burghart, et al., 2019). Using the

built-in accelerometer of a mobile device, Sway allows for the collection of more accurate and consistent measures compared to touch-screen cognitive tests. Using the built-in motion sensors of the device, at a frequency of 500 to 1000 hertz (one to two milliseconds), Sway can measure within millisecond precision. Sway's patented method identifies the initial movement in response to a stimulus by detecting motion exceeding a threshold and identifies the first intentional motion in a given vector. Collectively, the Sway application technology is an innovative solution to obtain objective, valid, reliable, and accurate balance and cognitive assessment data.

Previous normative data studies by Anderson, et al. 2019 and Brett, et al. 2020 established normative values for Sway Balance and Reaction Time scores/values for males and females between the ages of five and 21. While informative, these studies were limited in normative data sample size (Anderson, et al. 2019 studied 486 athletes, Brett, et al. 2020 studied ~3700 Sway baseline samples).

The purpose of the current study was to establish more robust normative Sway Balance and Cognitive assessment data for males and females of expanded age ranges. Expanded Sway normative data is likely to be beneficial for clinicians serving older patient populations.

MATERIALS AND METHODS

Design and Setting

Mobile devices with Android and iOS operating systems have been used to collect Sway Balance and Cognitive data during in-person and remote settings. Sway users of all ages and various geographic locations have completed Sway Balance and Cognitive baseline assessments in order to monitor post-event balance and/or cognitive performance. This research leveraged data stored within Sway Medical's database of baseline tests.

Study Population

The study consisted of 165,492, 149,368, 55,492, 55,074, and 44,836 Sway users who completed a Sway Balance, Reaction Time, Impulse Control, Inspection Time, and/or Memory Baseline testing protocol, respectively (Tables 2-6). Approximately 59% of the total normative data were collected from

males. A majority of the normative data population consisted of individuals aged 14 to 25.

The Sway baseline collection protocol requires an individual complete one familiarization trial and then two to three additional trials. The familiarization trial is excluded, and an average of the remaining trials is used as an individual's baseline Sway Balance or Cognitive assessment score or value. Consequently, baseline data were excluded if an individual completed only two trials, or greater than four baseline trials.

Measures and Procedures

Baseline Test Session Protocols

Balance Protocol

The user presses the mobile device against their chest and total postural stability, as well as raw acceleration waveforms, are measured during a modified Balance Error Scoring System (mBESS) protocol. The mBESS protocol requires a subject to stand and maintain balance while eyes are closed and feet together, during tandem stances (left foot front, right foot front), and single leg balance stances (left leg, right leg). The Sway balance score is a composite score that averages stability across all stances.

Instructions:
- Ex. "Stand with your feet together and eyes closed."

Motion Reaction Time Assessment

The Sway motion reaction time assessment ("Reaction Time") is a measure of basic sensory processing and neuromotor response speed. The test measures an individual's ability to detect a change in the color of the screen and quickly initiate a movement of the device. Simple reaction time (SRT) is the amount of time it takes to complete this task. Users stand in an upright position, while holding the mobile device with both hands. Users are instructed to react to changes in the screen color by quickly shaking the device. Users then perform SRT trials using the Sway Reaction Time test. Latent response times, the difference between the color change and the onset of user-initiated tilt of the mobile device, are recorded in milliseconds (ms). Users completed two (2) trials of Sway Reaction Time testing, containing five (5) SRT tests

each. Reaction time scores are determined from five (5) trials, measured in milliseconds. The fastest and slowest trials were dropped and the average of the three (3) remaining trials were used in testing.

Instructions:
- "When the screen turns orange, move the device as fast as you can in any direction."

Impulse Control Assessment

The Sway Impulse Control test quantifies an individual's inhibitory processing time by presenting the user with either a go stimulus requiring a motion response, or a no-go stimulus requiring no response. Users are asked to move the smart device as rapidly as possible in any direction when a target was presented on the screen.

Instructions:
- "When you see the green check mark, move the device quickly in any direction."
- "When you see the red x, keep the device still."

Inspection Time Assessment

The Sway Inspection Time assessment is a measure of rapid visual processing speed. Two T-shaped lines are presented, one twice the length of the other, for a short duration of time before they are masked. Users are asked to touch the side of the screen with the longest line. The duration of time before the lines are masked was reduced as the user correctly identified which line is longer.

Instructions:
- "Two lines will be displayed before being masked. Tap the device on the side with the longer line."

Memory Assessment

The Sway Memory assessment measures visuospatial working memory. The test presents users with a sequence of three consonants for 15 seconds. After the 15 seconds, the user is asked to complete a working memory task by tracking a sequence of lighted squares. Once complete, the user was asked to recall the original three letter sequence.

Instructions:
- "Press begin test to reveal the three-letter sequence. You have 3 seconds to memorize the letters."

- "Watch the sequence until it is complete, then repeat the sequence."

Statistical Analyses

Data Preparation

Individuals may be directed or choose to update their baseline Sway score/values following developmental milestones and/or prior to the initiation of a new sports or clinical activity. Consequently, baseline data was sorted by date of trial completion (with older tests appearing first) prior to normative value calculations.

Sway Balance Data Preparation

An average of all five mBESS Sway balance stance scores were then calculated and the first baseline trial (familiarization) was removed.

Sway Cognitive Data Preparation

Extreme reaction time and impulse control outlying values over two seconds (or 2000ms) were removed from normative value consideration. Inspection time data over 700ms were also filtered from the data set.

Normative Analysis

Mann-Whitney U statistical tests were used to explore inter- and intra-sex and age differences in Sway Balance and Cognitive assessment scores/values. Descriptive statistics (mean, standard deviation, median, and interquartile range [10th, 25th, 75th, and 90th]) were calculated for all Sway tests (Tables 2 through 6). All statistical testing was performed using the Matlab (Mathworks, Inc.) Statistics and Machine Learning Toolbox. Statistical significance was set a priori at a p-value of 0.05. Only those baseline normative samples >=50 in size for each age grouping were considered for normative analysis.

RESULTS

Primary Analyses

In a comparison of male and female Sway users of all ages, a statistically significant difference in Sway Balance and Reaction Time scores/values at baseline was found (Balance, M - 78.8 ± 15.0, F - 84.4 ± 13.0 [p<.005]; Reaction Time, M – 254.8 ± 73.2, F – 275.5 ± 79.9 [p<.005]) (Table 1).

Additionally, Sway Balance and Reaction Time scores/values for males and females of the same age group vary significantly from nine to 30 years of age (p<.005). In fact, significant differences in Sway Reaction Time between males and females exist between all age groupings with the exception of users aged 61-70. Statistical comparison of Sway Balance baseline scores between the ages of nine and 70 y.o. reveal distinct trends (Tables 2 and Figure 1, below). Specifically, subsequent age group comparisons (Male 11 vs. 12 y.o., Female 11 vs. 12 y.o., etc.) from age 11 through age 18, for males and females, produce significant statistical differences. These differences extend further into younger age ranges for males (nine vs. 10 y.o., p<.005; 10 vs. 11 y.o., p<.005). As seen in Figure 1, Sway Balance scores plateau between the ages of 18 and 25 y.o. for males and 18 and 30 y.o. for females. This is followed by a clear downward decline in Sway Balance scores that accompany normal aging. Notably, normative samples for Sway's Reaction Time assessment extends into the 71-80 age range – a result of ease of use for older individuals.

Table *1*: *Male – Female Differences in Sway Tests*

Sway Test	Male	Female	p-value
Balance	78.8±15.0	84.4±13.0	P < .005
Reaction Time	254.8±73.2	275.5±79.9	P < .05
Impulse Control	336.6±79.8	350.9±75.6	n.s.
Inspection Time	61.7±35.5	67.5±35.1	n.s.
Memory	68.7±13.5	69.5±12.2	n.s.

p-value, Man-Whitney U-test significance

Similar trends and statistical distinctions exist between sex and numerous age groups for individuals performing Sway's Cognitive - Impulse Control, Inspection Time, and Memory – baseline assessments (Tables 3-6 and Figure 2-5, below). Sway's Impulse Control and Inspection Time baseline normative data are limited to ages 10 through 25, due to fewer than 50 available individual baseline assessments in the Sway database. Normative Sway Memory baseline data is limited to age ranges 11 to 25 for the same reason. Statistically significant differences between males and females are not found to occur until age 21 to 25.

As with Sway Balance scores, Sway's Cognitive assessments demonstrate similar functional peaking

in performance assessment scores/values between the ages 18 and ~25, followed by a diminution in performance over time.

SUMMARY

Normative values for Sway Balance and Cognitive tests have presently been established and expanded beyond previously defined age ranges. Sway Balance and Reaction Time scores/values differ significantly among males and females, overall. Additionally, as expected, Sway Balance and Cognitive functional assessment performance improve during late stage childhood and adolescence, plateau during early adulthood, and then are followed by a steady senescent decline. These new robust normative Sway data should support balance and cogntive assessment evaluation of a broader range of individuals without prior baseline data.

TABLE 2. Descriptive Statistics for Sway Balance Scores																			M-F
	Males									Females									
	Number	Mean	Median	SD	Percentiles				p	Number	Mean	Median	SD	Percentiles				p	p
					10th	25th	75th	90th						10th	25th	75th	90th		
Total sample	99214	78.8	82.5	15.0	57.9	71.1	90.0	94.4	-	66278	84.4	88.1	13.0	67.0	79.1	93.6	96.6	-	***
Age 9	498	62.5	62.9	18.1	37.3	50.9	75.6	86.4	-	220	74.2	77.8	15.8	52.7	64.3	85.8	92.9	-	***
Age 10	711	66.0	67.5	17.0	41.7	54.8	78.7	87.9	***	479	74.4	77.5	15.7	53.1	65.7	86.3	92.3	n.s.	***
Age 11	1316	68.8	70.5	16.7	46.5	57.9	81.8	89.5	***	943	75.8	79.1	15.6	53.5	67.9	88.1	93.0	n.s.	***
Age 12	2749	70.1	72.9	17.5	45.8	60.2	83.4	90.2	***	2000	78.9	82.4	15.0	58.1	71.0	90.2	94.1	***	***
Age 13	3510	73.0	75.9	16.8	50.5	63.5	85.8	91.6	***	2301	79.6	83.5	15.5	58.6	71.9	90.9	95.2	**	***
Age 14	10152	74.2	77.6	16.2	51.6	65.3	86.5	91.9	***	7017	81.6	85.4	14.1	61.9	75.0	92.0	95.5	***	***
Age 15	9876	76.1	79.4	15.6	54.8	67.6	87.9	93.1	***	6362	82.4	86.0	13.6	63.7	76.3	92.2	95.8	***	***
Age 16	8409	78.5	82.1	14.9	57.4	70.8	89.9	94.2	***	5091	83.6	87.3	13.5	65.9	78.0	93.4	96.6	***	***
Age 17	8557	79.6	83.2	14.6	59.6	72.2	90.4	94.6	***	5323	84.8	88.4	12.9	67.8	79.8	93.9	96.8	***	***
Age 18	18586	81.6	84.7	13.1	63.5	75.3	91.2	95.0	***	14293	86.7	89.8	11.2	72.3	82.3	94.5	97.1	***	***
Age 19	11546	81.5	84.7	13.4	63.4	75.1	91.3	95.1	n.s.	8000	86.4	89.6	11.5	71.8	81.8	94.3	97.1	n.s.	***
Age 20	8772	81.6	84.9	13.4	63.0	75.4	91.4	95.3	n.s.	6364	86.5	89.7	11.6	71.4	82.2	94.3	97.0	n.s.	***
Age 21-25	12963	81.7	85.0	13.2	63.5	75.3	91.4	95.1	n.s.	6646	86.3	89.6	11.6	71.7	82.0	94.4	97.0	n.s.	***
Age 26-30	581	83.2	86.7	13.1	64.3	77.1	92.9	96.3	***	349	86.1	89.5	13.2	71.3	82.8	94.3	97.1	n.s.	***
Age 31-40	405	81.1	85.6	15.4	58.2	73.6	92.1	96.6	n.s.	371	83.0	86.2	13.5	63.0	76.7	93.3	96.7	***	n.s.
Age 41-50	261	78.5	83.2	17.2	54.2	69.5	91.3	96.9	n.s.	238	80.2	84.2	15.4	58.7	72.2	92.0	96.1	*	n.s.
Age 51-60	158	74.2	77.4	15.8	50.4	64.6	86.8	92.8	***	163	75.4	79.5	17.5	50.7	65.1	88.8	95.5	***	n.s.
Age 61-70	84	68.0	70.5	18.0	45.1	58.3	81.6	89.3	**	71	70.6	74.3	19.0	39.4	59.5	86.2	90.0	n.s.	n.s.

Scores between the 25th and 75th percentile are considered the "average" classification range. Male and female p columns, Mann-Whitney U-test level of significant difference from previous age. M-F - p column, Mann-Whitney U-test level of significant difference between males and females of the same age. ***, P <.005; **, P <.01; *, P <.05; n.s., no significant difference.

TABLE 3. Descriptive Statistics for Sway Reaction Time Values																		M-F
	Males									Females								
	Number	Mean	Median	SD	Percentiles				p	Number	Mean	Median	SD	Percentiles				p	p
					10th	25th	75th	90th						10th	25th	75th	90th		
Total sample	89488	254.8	240.7	73.2	330.3	280.0	211.7	190.7	-	59880	275.5	259.7	79.9	361.5	305.3	226.7	203.3	-	**
Age 9	419	339.8	330.7	94.3	444.8	383.3	278.7	240.2	-	190	351.1	345.8	80.9	458.3	399.7	293.0	253.5	-	***
Age 10	616	316.2	304.3	80.2	411.4	355.3	255.8	233.0	***	411	339.0	327.0	90.9	451.7	385.9	275.9	236.3	*	***
Age 11	1125	295.1	279.5	81.1	389.7	329.5	241.0	214.5	***	775	327.1	310.0	107.9	446.0	366.9	262.0	230.5	***	***
Age 12	2438	280.8	264.3	83.0	370.5	313.5	231.0	206.1	***	1812	303.9	286.0	91.0	397.1	341.8	247.4	218.0	***	***
Age 13	2952	272.2	258.0	75.8	355.3	303.0	224.2	200.2	***	2020	296.3	277.6	92.9	393.8	331.5	240.5	212.7	***	***
Age 14	8991	262.8	247.7	76.0	343.8	291.0	217.0	195.0	***	6316	283.4	266.0	86.6	374.0	315.0	230.3	206.0	***	***
Age 15	8849	260.2	246.3	75.2	336.0	288.0	215.7	193.7	**	5655	283.7	266.3	87.0	378.0	315.7	230.0	205.7	n.s.	***
Age 16	7514	257.5	243.0	79.2	333.0	283.0	214.0	192.0	***	4445	279.2	264.3	76.9	367.5	311.7	228.0	203.7	*	***
Age 17	7783	251.9	240.0	68.4	324.7	277.0	210.5	189.5	***	4808	272.9	258.5	80.3	355.4	302.7	225.7	201.0	***	***
Age 18	16891	245.5	234.0	62.9	312.1	269.0	206.7	187.3	***	13195	264.3	252.3	65.8	340.0	292.0	222.5	200.5	***	***
Age 19	10667	245.3	233.3	64.2	313.0	267.0	207.3	188.0	n.s.	7335	265.0	253.7	64.6	339.3	292.0	223.7	201.7	n.s.	***
Age 20	8010	245.8	233.6	66.4	310.2	268.0	208.0	189.2	n.s.	5750	264.1	251.7	69.2	338.2	289.5	221.7	200.7	*	***
Age 21-25	11875	247.5	235.5	70.0	314.0	270.0	208.3	188.3	n.s.	6043	265.1	252.3	69.4	341.0	292.3	223.0	200.7	n.s.	***
Age 26-30	488	268.0	248.0	103.7	341.0	292.0	217.8	193.9	***	286	283.4	267.0	78.5	376.0	311.5	233.0	208.6	***	***
Age 31-40	336	287.8	260.3	97.2	405.1	313.8	227.5	202.7	***	265	316.5	284.3	137.0	447.0	340.5	246.4	216.7	***	***
Age 41-50	206	302.0	260.2	147.1	413.3	332.3	226.7	202.1	n.s.	186	334.2	311.2	120.8	485.4	376.0	255.0	219.1	*	***
Age 51-60	145	319.7	295.0	121.6	469.5	370.0	236.0	203.5	*	156	367.1	321.0	174.8	564.6	394.0	276.3	235.1	***	***
Age 61-70	102	390.1	341.5	169.7	547.0	446.0	292.0	237.8	***	121	442.3	385.0	223.2	727.5	499.6	282.5	243.9	***	n.s.
Age 71-80	51	428.1	394.0	173.0	690.2	487.9	315.9	268.6	n.s.	59	482.1	463.0	141.9	696.1	556.4	363.4	321.0	***	***

Scores between the 25th and 75th percentile are considered the "average" classification range. Male and female p columns, Mann-Whitney U-test level of significant difference from previous age. M-F - p column, Mann-Whitney U-test level of significant difference between males and females of the same age. ***, P <.005; **, P <.01; *, P <.05; n.s., no significant difference.

TABLE 4. Descriptive Statistics for Sway Impulse Control Values																		M-F
	Males									Females								
	Number	Mean	Median	SD	Percentiles				p	Number	Mean	Median	SD	Percentiles				p	p
					10th	25th	75th	90th						10th	25th	75th	90th		
Total sample	32251	336.6	321.3	79.8	413.5	362.0	290.5	267.3	-	23241	350.9	336.7	75.6	433.0	380.0	303.7	279.0	-	n.s.
Age 10	57	455.6	417.0	128.0	679.3	496.1	368.5	327.0	-	77	439.6	414.7	112.8	581.1	480.2	378.0	325.4	-	***
Age 11	161	404.6	379.7	134.0	492.2	438.0	340.3	311.6	***	134	430.8	403.9	114.8	564.9	463.7	364.0	329.0	n.s.	***
Age 12	583	391.7	364.7	107.8	499.5	423.8	327.7	298.9	*	546	399.5	381.2	93.6	511.1	436.7	339.0	306.8	***	***
Age 13	771	373.2	354.0	97.6	468.6	404.8	313.3	288.3	***	669	397.3	374.3	103.5	517.6	433.7	333.0	300.8	n.s.	***
Age 14	2530	354.4	337.3	90.9	442.3	384.0	302.0	276.5	***	2170	371.8	352.5	93.4	463.7	400.3	317.0	288.7	***	***
Age 15	2729	348.7	331.7	87.0	431.0	375.4	298.0	273.3	***	2065	360.5	345.3	81.0	446.7	392.8	309.3	282.7	***	***
Age 16	2501	340.6	323.3	83.2	416.5	367.0	292.9	269.2	***	1624	355.9	341.7	78.5	439.3	385.2	307.2	282.0	n.s.	***
Age 17	2625	336.8	321.3	83.1	411.0	361.1	292.7	268.7	n.s.	1739	350.0	335.3	73.7	424.5	377.7	304.7	281.3	**	***
Age 18	6006	329.8	316.7	72.4	400.3	355.7	287.7	265.7	***	4588	341.9	330.3	63.6	418.2	370.3	300.0	277.0	***	***
Age 19	4502	327.2	315.7	68.7	395.8	351.0	286.0	264.3	***	3506	339.0	329.3	63.5	410.6	366.0	299.0	275.3	n.s.	***
Age 20	5713	328.3	314.3	74.6	401.1	352.7	285.3	263.0	n.s.	2849	338.8	329.3	63.4	413.9	366.7	297.0	273.3	n.s.	***
Age 21-25	115	351.5	328.3	98.5	427.7	384.3	299.3	263.7	n.s.	3134	340.0	327.7	67.5	413.0	366.7	298.3	275.0	n.s.	***
Age 26-30	50	348.3	343.8	41.4	403.0	371.7	321.3	296.8	***	58	349.9	338.5	60.4	404.9	383.3	308.0	283.0	n.s.	***

Scores between the 25th and 75th percentile are considered the "average" classification range. Male and female p columns, Mann-Whitney U-test level of significant difference from previous age. M-F - p column, Mann-Whitney U-test level of significant difference between males and females of the same age. ***, P <.005; **, P <.01; *, P <.05; n.s., no significant difference.

TABLE 5. Descriptive Statistics for Sway Inspection Time Scores																				M-F
	Males									Females										
	Number	Mean	Median	SD	Percentiles				p	Number	Mean	Median	SD	Percentiles				p	p
					10th	25th	75th	90th						10th	25th	75th	90th		
Total sample	31949	61.7	56.7	35.5	102.0	73.7	39.7	28.3	-	23125	67.5	62.3	35.1	107.7	85.0	45.3	34.0	-	n.s.
Age 10	56	100.5	90.7	44.0	163.8	119.0	70.8	57.0	-	77	105.1	90.7	49.5	187.0	133.2	73.7	51.0	-	n.s.
Age 11	158	84.5	79.3	43.6	141.7	102.0	56.7	34.0	**	131	97.5	90.7	45.1	153.0	119.0	68.0	45.3	n.s.	**
Age 12	579	82.4	73.7	40.2	130.3	96.3	56.7	39.7	n.s.	545	85.6	79.3	38.3	130.3	102.0	62.3	42.5	**	*
Age 13	765	76.7	68.0	39.7	124.7	90.7	51.0	39.7	***	664	81.2	73.7	37.3	124.7	96.3	56.7	39.7	***	***
Age 14	2516	69.2	62.3	37.8	113.3	85.0	45.3	28.3	***	2171	75.1	68.0	38.9	119.0	90.7	51.0	34.0	***	***
Age 15	2717	67.3	62.3	37.4	112.8	79.3	39.7	28.3	*	2070	73.8	68.0	38.0	119.0	90.7	51.0	34.0	n.s.	***
Age 16	2488	64.7	56.7	37.8	107.7	79.3	39.7	28.3	***	1622	72.0	62.3	39.6	113.3	90.7	45.3	34.0	*	***
Age 17	2616	63.6	56.7	35.6	107.7	79.3	39.7	28.3	n.s.	1739	68.0	62.3	34.3	107.7	85.0	45.3	34.0	**	***
Age 18	5944	57.5	51.0	31.1	90.7	68.0	39.7	28.3	***	4560	62.8	56.7	31.3	96.3	79.3	39.7	28.3	***	***
Age 19	4466	57.6	51.0	33.4	93.5	68.0	34.0	28.3	n.s.	3483	62.7	56.7	30.2	96.3	79.3	39.7	28.3	n.s.	***
Age 20	3823	57.1	51.0	32.4	90.7	68.0	34.0	28.3	n.s.	2837	63.1	56.7	33.4	102.0	79.3	39.7	28.3	n.s.	***
Age 21-25	5628	58.5	51.0	35.1	96.3	68.0	34.0	28.3	n.s.	3092	63.0	56.7	31.9	102.0	79.3	39.7	28.3	n.s.	***
Age 26-30	107	64.6	56.7	42.0	119.0	85.0	34.0	22.7	n.s.	55	66.1	56.7	42.8	107.7	79.3	39.7	28.3	n.s.	n.s.

Scores between the 25th and 75th percentile are considered the "average" classification range. Male and female p columns, Mann-Whitney U-test level of significant difference from previous age. M-F - p column, Mann-Whitney U-test level of significant difference between males and females of the same age. ***, P <.005; **, P <.01; *, P <.05; n.s., no significant difference.

TABLE 6. Descriptive Statistics for Sway Memory Scores																			M-F
	Males									Females									
	Number	Mean	Median	SD	Percentiles				p	Number	Mean	Median	SD	Percentiles				p	p
					10th	25th	75th	90th						10th	25th	75th	90th		
Total sample	26041	68.7	72.0	13.5	54.7	67.0	76.0	80.0	-	18795	69.5	72.0	12.2	57.7	68.0	76.0	80.0	-	n.s.
Age 11	86	57.8	65.7	19.7	25.0	46.7	71.0	76.9	-	95	57.9	67.3	20.0	25.0	45.3	72.0	75.0	-	n.s.
Age 12	421	61.8	68.0	17.5	25.0	57.6	73.0	77.0	n.s.	385	62.6	69.0	16.7	33.3	60.1	73.0	76.0	n.s.	n.s.
Age 13	591	62.7	69.0	17.0	35.6	58.4	73.0	77.0	n.s.	444	64.5	70.0	15.8	39.9	62.2	74.0	78.0	n.s.	n.s.
Age 14	1656	66.0	70.0	14.6	46.7	64.3	74.0	78.0	***	1428	66.8	71.0	13.5	50.7	65.0	74.0	77.0	*	n.s.
Age 15	1885	66.8	71.0	14.0	49.3	65.0	75.0	78.0	*	1351	67.2	71.0	13.4	52.6	66.0	74.0	77.0	n.s.	n.s.
Age 16	1724	67.2	71.0	13.8	51.7	65.0	75.0	79.0	n.s.	1068	68.1	71.0	13.2	54.2	66.3	75.0	79.0	n.s.	n.s.
Age 17	1810	68.2	71.0	13.5	54.8	66.3	75.0	79.0	*	1206	68.7	71.0	12.6	55.7	67.0	75.0	79.0	n.s.	n.s.
Age 18	4947	69.8	72.0	12.4	57.0	68.0	76.0	80.0	***	3969	70.7	72.0	10.9	61.3	68.5	76.0	80.0	***	n.s.
Age 19	4128	70.3	72.7	12.2	59.3	68.0	77.0	81.0	*	3279	70.9	73.0	11.1	61.3	69.0	77.0	80.0	*	n.s.
Age 20	3517	70.2	72.0	12.5	58.7	68.0	77.0	81.0	n.s.	2656	70.9	73.0	10.9	61.3	68.3	76.0	80.0	n.s.	n.s.
Age 21-25	5075	69.4	72.0	13.6	57.0	68.0	76.0	80.5	n.s.	2780	70.9	72.0	11.3	61.8	69.0	76.0	80.5	n.s.	**

Scores between the 25th and 75th percentile are considered the "average" classification range. Male and female p columns, Mann-Whitney U-test level of significant difference from previous age. M-F - p column, Mann-Whitney U-test level of significant difference between males and females of the same age. ***, P <.005; **, P <.01; *, P <.05; n.s., no significant difference.
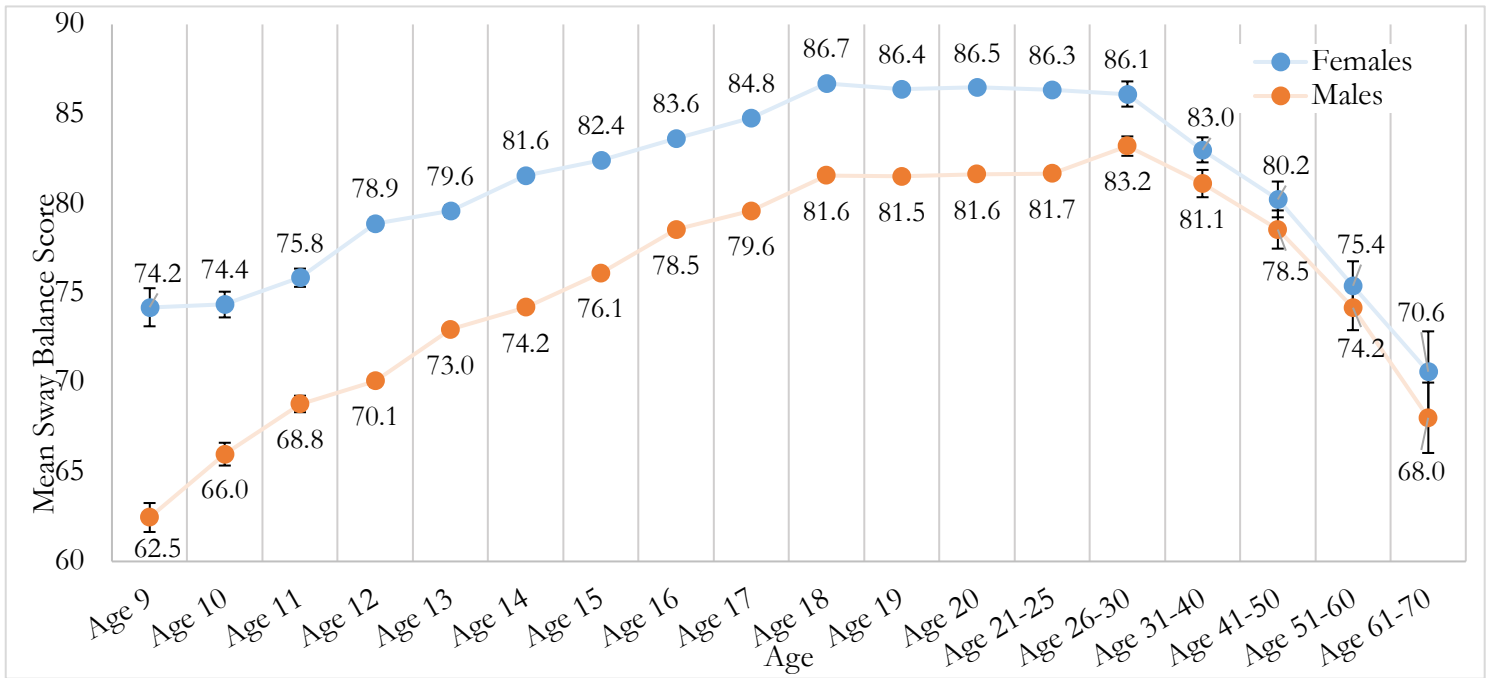
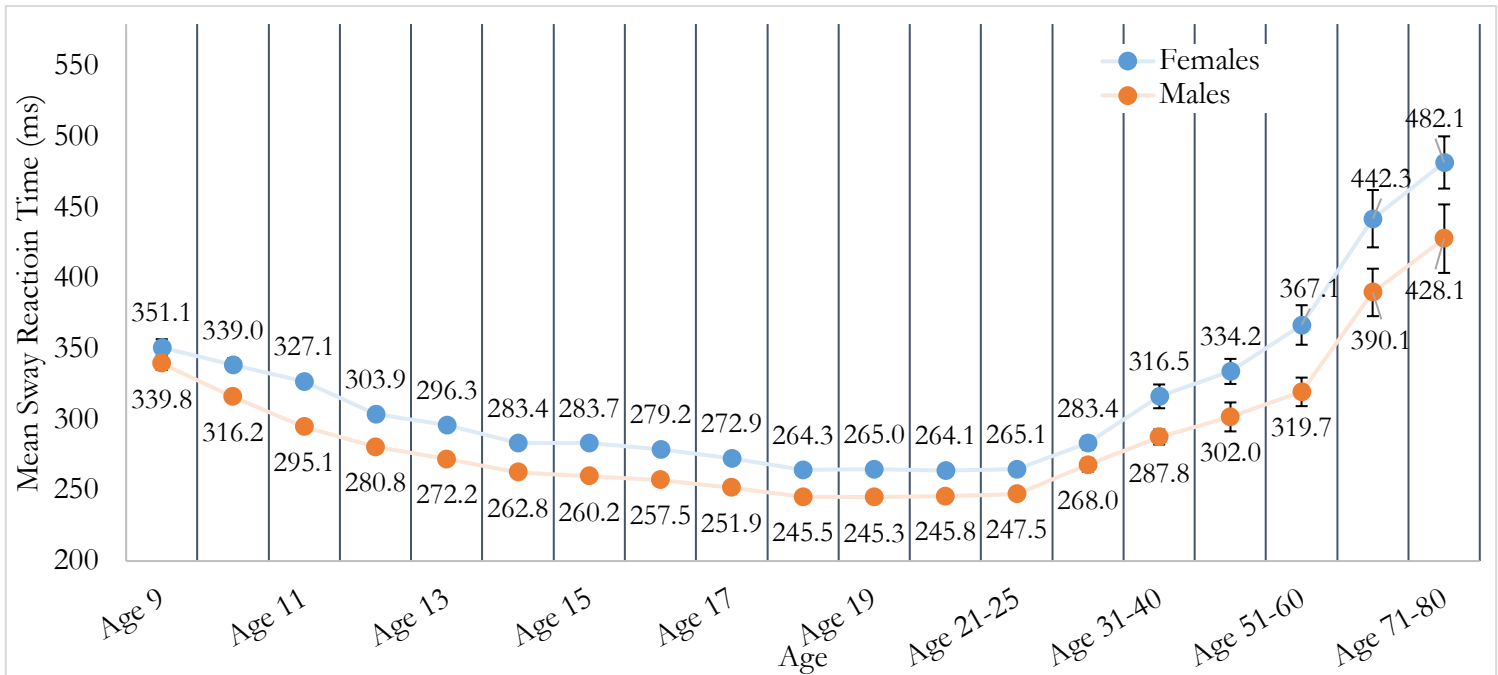*Figure 1: Normative Sway Balance Scores, 9 to 70 years old*

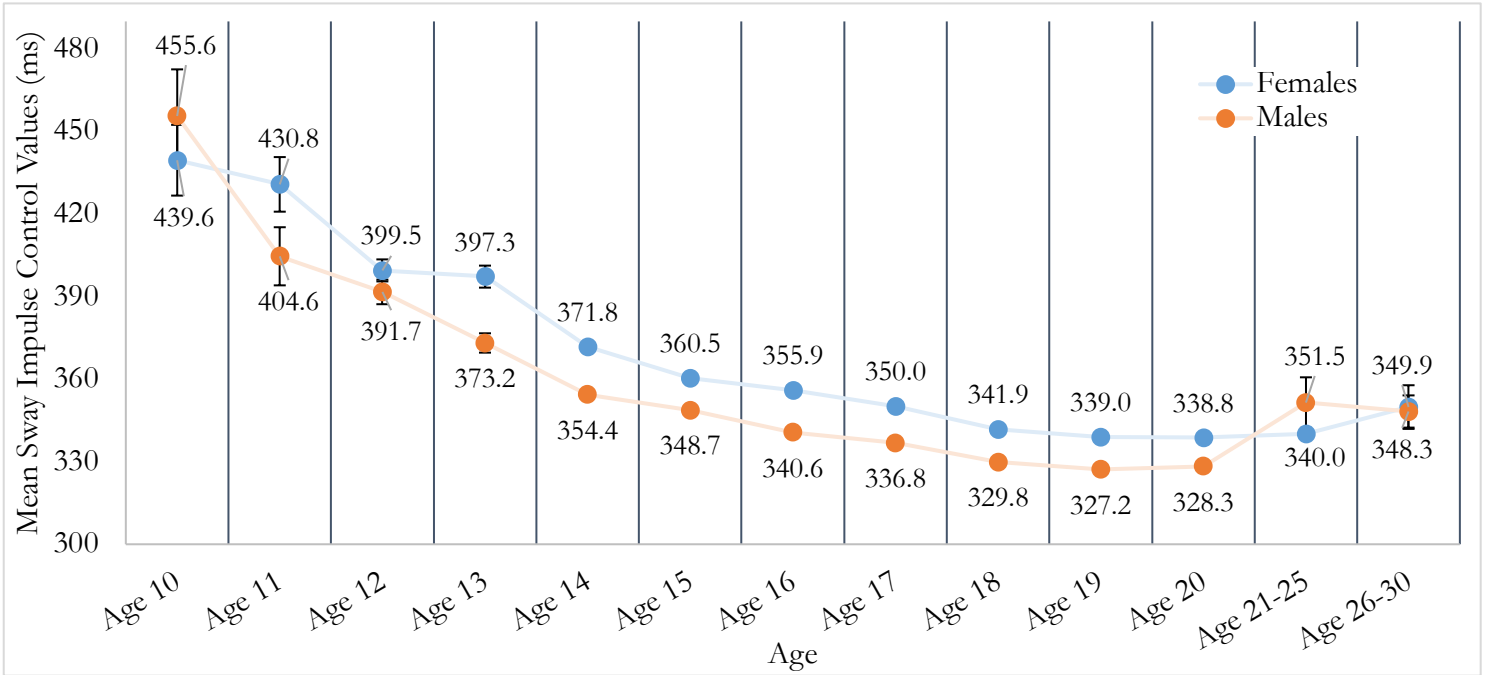*Figure 2: Normative Sway Reaction Time Values, 9 to 80 years old*

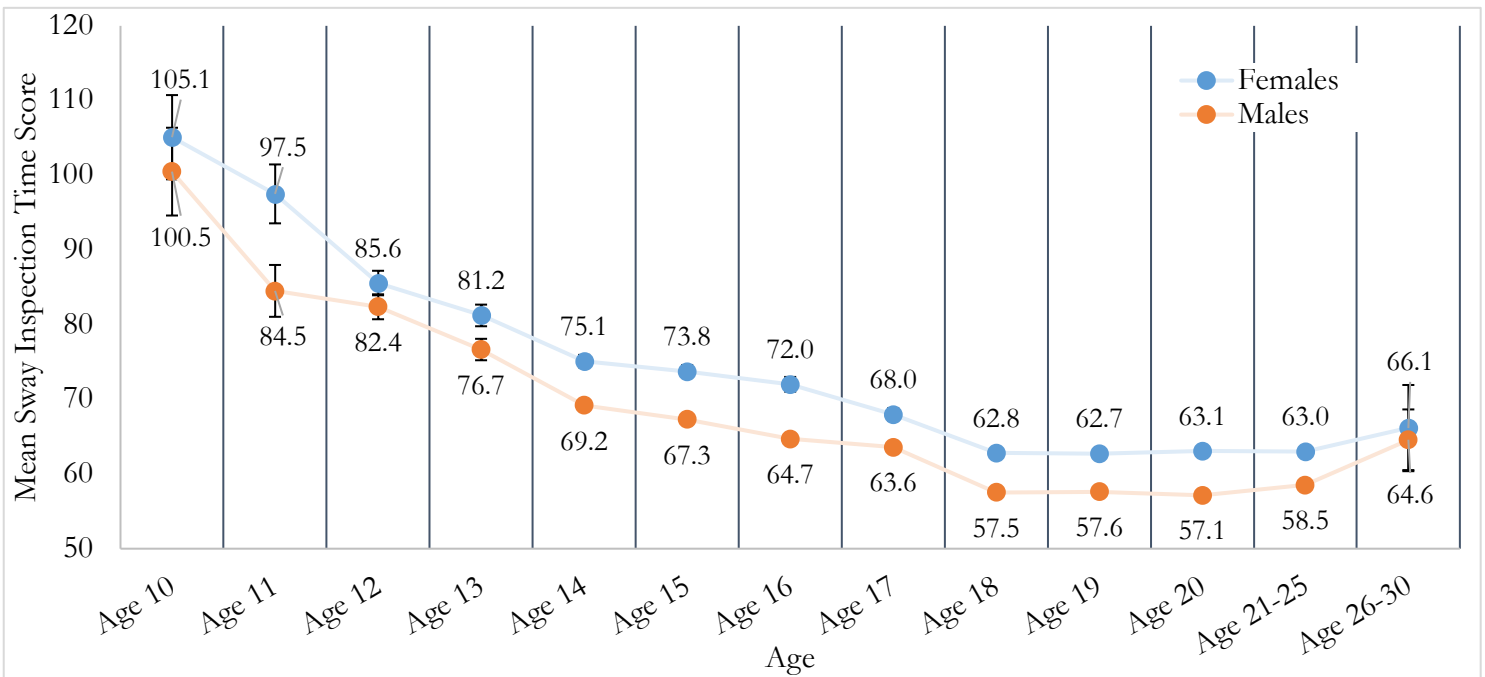Figure 3: Normative Sway Impulse Control Values, 10 to 30 years old

Figure 4: Normative Sway Inspection Time Scores, 10 to 30 years old
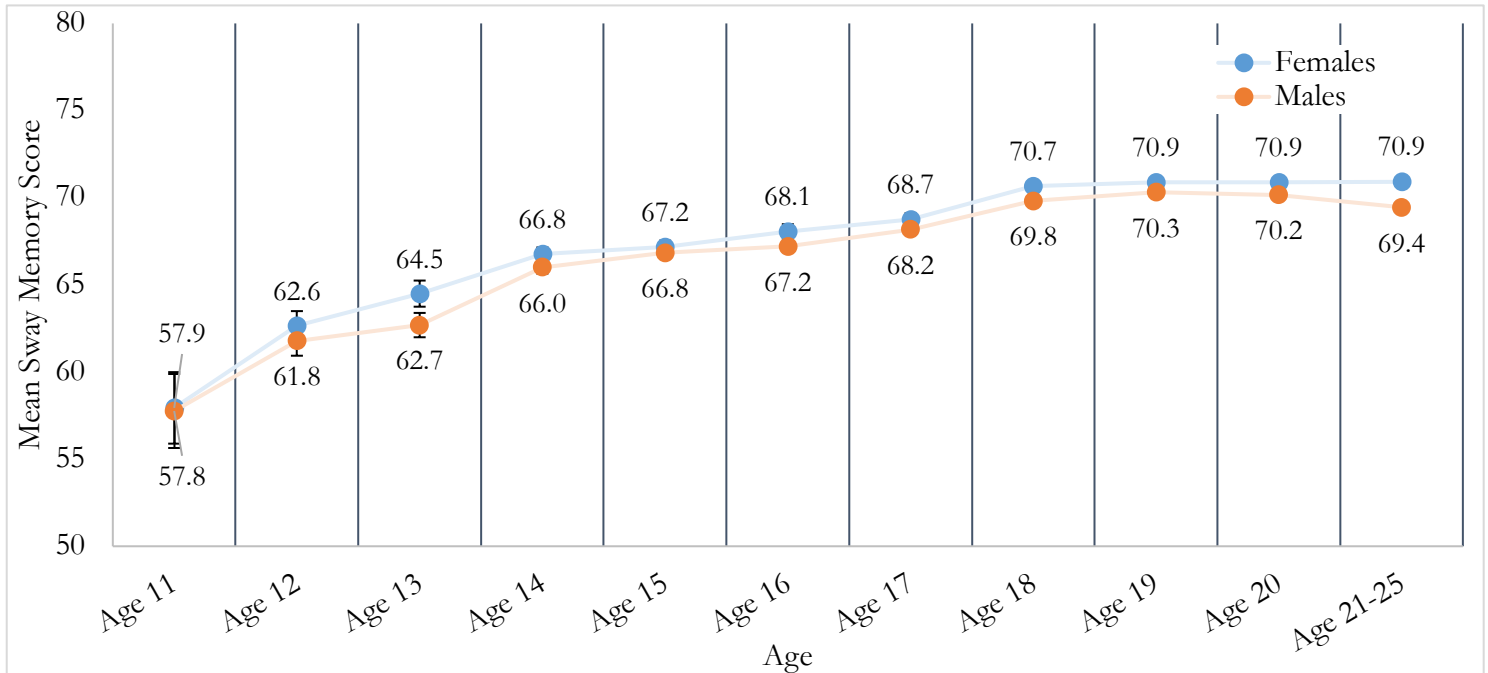
Figure 5: Normative Sway Memory Scores, 11 to 25 years old

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