

Table 148. Tensile properties of human hair

Hair	Age Group										Adult Average
	0-9 yr	10-19 yr	20-29 yr	30-39 yr	40-49 yr	50-59 yr	60-69 yr	70-79 yr	80-89 yr		
<i>Tensile Breaking Load (g)</i>											
Ratio	Head	84	160	172	155	138	119	94	80	78	119
	Pubic	—	—	160	155	145	120	—	—	—	—
	Head	0.49	0.93	1.00	0.90	0.80	0.69	0.55	0.47	0.45	—
	Pubic	—	—	1.00	0.96	0.91	0.75	—	—	—	—
<i>Ultimate Tensile Strength (kg/mm²)</i>											
Ratio	Head	14.5	21.3	22.3	23.0	23.0	23.0	17.4	15.1	14.4	19.7
	Pubic	—	—	21.2	20.7	19.0	17.6	—	—	—	—
	Head	0.63	0.93	0.97	1.00	1.00	1.00	0.76	0.66	0.63	—
	Pubic	—	—	1.00	0.98	0.90	0.83	—	—	—	—
<i>Ultimate Percentage Elongation</i>											
Ratio	Head	40	46	43	43	39	39	39	39	39	40
	Pubic	—	—	44	42	40	34	—	—	—	—
	Head	0.87	1.00	0.93	0.93	0.85	0.85	0.85	0.85	0.85	—
	Pubic	—	—	1.00	0.95	0.91	0.77	—	—	—	—

The breaking load of axillary hair is 98 g between 20 and 59 years of age and less in females than in males. The breaking load of pubic hair is likewise greatest in the 20 to 29 age group but, by 50 to 59 years of age, has decreased to 75% of its maximum. In females it is less than that in males. There are no significant differences between the breaking load of head and pubic hair, both being much less than that of axillary hair. The impulsive tensile breaking load approximately equals the tensile breaking load in a normal test.

The ultimate tensile strength of head hair is greatest at 30 to 59 years of age and least by 80 to 89 years of age (63%). There is no significant sexual difference in the ultimate strength of Japanese hair. The ultimate strength of American hair is a little less than that of Japanese hair. The hair of men 6 years after exposure to atomic radiation has an ultimate strength approximately equal to that of normal men. There are no differences in the ultimate strength of hair from the frontal, parietal, temporal, or occipital region of the head. The ultimate strength of fallen hair is three-fourths of that

of normal hair in situ. The ultimate strength of hair decreases 10% after storage in water for 1 day and 15% after 5 days.

Axillary hair has an ultimate strength of 19.4 ± 0.20 kg/mm² between 20 and 59 years of age with no sexual differences. The ultimate strength of pubic hair is greatest in the 20 to 29 age group but in the 50 to 59 age group is only 83% as strong. There is no significant sexual difference in the ultimate strength of pubic hair. The ultimate strength of axillary and pubic hair is greater than that of head hair, but the variation is not significant.

The ultimate percentage elongation of head hair is greatest at 10 to 19 years of age. In people over 40 years of age the elongation is 85% of its value in the 10 to 19 age group. There is no sexual difference in the ultimate elongation. American and Japanese hair have the same ultimate elongation. Hair of a man 6 years after exposure to atomic radiation and that of a normal man show no significant difference in the ultimate elongation. The elongation of hair from the frontal, parietal, temporal, and occipital regions of the head shows no regional differences.

Fallen hair has an ultimate elongation about five-sixths of that of normal hair in situ. The ultimate elongation decreases 10% by storage in water for 1 day and 15% after 5 days.

The ultimate elongation of axillary hair is $36 \pm 0.7\%$ between 20 and 59 years of age, showing no significant sexual differences. Pubic hair has an ultimate elongation that is greatest in the 20 to 29 age group and least after 50 years of age (77%). There is no significant difference in the ultimate elongation of axillary and pubic hair, each of which is much greater than that of head hair.

Endo investigated the effect on the ultimate tensile strength and percentage elongation of human head hair, stored at room temperature. His results for different time intervals are given in Table 149.

Stress-strain curves of different kinds of hair are shown in Fig. 211. The elongation at the same stress decreases with aging.

The percentage of elastic recovery for head hair is 52%, just before rupture and immediately after removal of stress, and 64% with the elastic aftereffect.

The creep limit is 55% of the ultimate strength for head hair. Maximum creeping time is 60 minutes. The creeping breaking elongation is greater than the ultimate elongation in a normal test.

REFERENCES

- Endo, N.: Study on the strength of the human hair and the mammal hair. *J. Kyoto Pref. Med. Univ.*, 53: 373-389, 1953.
Yoshida, T., I. Bessho, and S. Okamoto: Supplemental report on the strength of human hair. *Med. J. Mutual Aid Ass.*, 8: 488-493, 1959.

Table 149. Tensile properties of human head hair stored at room temperature

Fresh Tissue	Storage Time		
	1 wk	6 mo	1 yr
<i>Ultimate Tensile Strength (kg/mm²)</i>			
22.8	22.8	22.4	22.3
<i>Ultimate Percentage Elongation</i>			
42.0	41.1	41.0	39.5

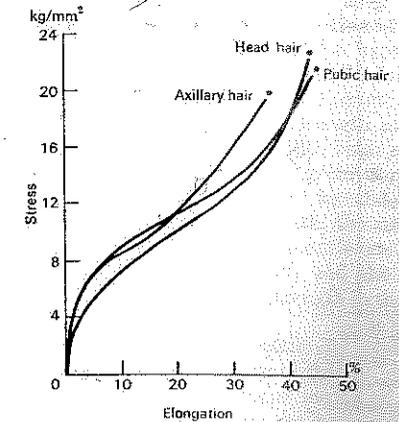


FIG. 211. Stress-strain curves in tension of the hair of persons 20 to 29 years of age.

7.5.1.2. Tensile Properties of the Hair of Animals (Table 150).

The tensile properties of the fallen hair of 20 kinds of mammals were studied by Endo (1953). The tensile breaking load of fallen hair is greatest (250-270 g) in antelopes, bears, and wolves; second (170-200 g) in deer, goats, foxes, dogs, and monkeys; third (130-160 g) in brown bears, badgers, lions, orangutans, and cats; and least (80-120 g) in tigers, martens, raccoon dogs, camels, and angora rabbits. Fallen head hair from humans has a breaking load between 80 and 120 g.

The ultimate tensile strength of fallen hair is greatest (25-30 kg/mm²) in bears, tigers, raccoon dogs, brown bears, orangutans, and cats; next (20-22 kg/mm²) in goats, dogs, foxes, camels, deer, antelopes, wolves, badgers, monkeys, and martens; and least (15-18 kg/mm²) in angora rabbits and lions. Fallen head hair from humans has an ultimate strength similar to that of angora rabbits and lions.

The ultimate percentage elongation of fallen hair is greatest (40% or over) in antelopes, lions, and wolves; next (30-39%) in monkeys, orangutans, goats, raccoon dogs, camels, deer, dogs, brown bears, foxes, tigers, martens, bears, and cats; and least (less than 30%) in badgers and angora rabbits. Fallen head hair from humans has