

# REVISITING THE ROLE OF RIGOR MORTIS IN ASSESSING POSTMORTEM INTERVAL

Dr Neha Chaudhary<sup>1</sup>, Dr Ashok Chanana<sup>2</sup>, Dr Kuldip Kumar<sup>3</sup>, Dr Merry Pal Kaur<sup>4</sup>, Dr Aashish Sharma<sup>5</sup>, Dr Jaspinder Pratap Singh<sup>6\*</sup>

1. Senior Resident, Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar.
2. Professor and Head, Dept of Forensic Medicine & Toxicology, Chintpurni Medical College, Bungal Pathankot.
3. Professor and Head, Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar.
4. Junior Resident, Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar.
5. Senior Resident, Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar.
6. Senior Resident, Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar.

## CORRESPONDING AUTHOR

*Dr Jaspinder Pratap Singh,  
Department of Forensic Medicine and Toxicology,  
Government Medical College, Amritsar.  
Email Id: [jaspinderpsingh@gmail.com](mailto:jaspinderpsingh@gmail.com)*

## ABSTRACT

**Aims and Objectives:** The aims of the study to know the factors like nourishment, temperature and humidity affecting the pattern rigor mortis in hospital deaths. The determination of time since death is an important factor into the inquiry of death of an individual. The rigor mortis is one such parameter that can help the medical fraternity to deduce the time since death as well as the position of the body at the time of death.

**Material and method:** The present prospective study of 100 medicolegal autopsy cases, was conducted on fully identified patients who died in Guru Nanak Dev Hospital Amritsar with effect from November 1, 2019 after taking permission from the institutional ethical committee and the institutional thesis committee.

**Results:** In April to June, fully developed rigor mortis was at postmortem interval of 16 hrs and 9 mins. The rigor was disappearing at an average duration of 25 hrs and 52 mins. The present study concluded that the onset of rigor mortis is slow and duration long in cold weather. Rigor mortis persists longer in cold wet air than in fresh dry air. It is prolonged by dry cold air and cold water. On the other hand the onset of rigor mortis is rapid due to heat, and the duration is short.

**Conclusion:** Environmental factors like temperature and humidity plays an important role in affecting the rigor mortis. Nourishment and age also contribute to the rigor mortis. It is to be noted that the usually taught standard rule of 12 does not always hold true in each case as process of rigor mortis influenced by many variables especially temperature and humidity.

*Keywords: Rigor Mortis, Post Mortem Interval, Nysten's Rule*

## INTRODUCTION

The determination of Postmortem Interval (PMI), that is the time elapsed between the death and the post mortem examination is one of the important questions in medicolegal autopsies, apart from giving the opinion regarding the cause of death and manner of death. The determination of time since death is more important in those cases in which death is unwitnessed, for example in accidental deaths especially in hit and run cases in secluded areas or during night hours, most of suicidal deaths and some of the homicidal deaths. [1]

According to Shapiro (1950, 1954), rigor mortis began at the same time in all muscles. Although the variation in the sizes of the different joints and muscles lead to the larger muscles taking longer to develop rigor mortis which gave the impression that rigor mortis progressed from proximal to distal in the body.<sup>9</sup>

Interpretation of rigor mortis is subjective and can be conducted by movement of the joints. If the joint moves with little force, the rigor is said to be present in moderate form. If the joint moves with more force, the rigor is said to be present in strong form. If the joint moves freely, it could be that either the rigor has not developed yet or has passed off. In such cases, if only the proximal parts show rigidity that means, the rigor is yet in developing phase whereas if only distal parts show rigidity, the rigor has already developed as is in disappearing phase. During the development of rigor, if extremities are moved, when death occurred < 8–12 h before, the rigor will fix the extremities in their new position. The rigidity will be less than in other symmetrical groups, which have not been disturbed. The stage of rigor mortis is followed by stage of secondary relaxation. This is marked by molecular death. In this there is complete relaxation of the muscles. This stage of secondary relaxation is supported by 3 theories: first theory states the action of muscles of alkaline liquids due to putrefaction. Second theory is about dissolution of myosin due to excessive acid production during rigor. The third theory is the theory of autodigestion. The secondary relaxation in heart may mimic pathologic dilatation or it could give the picture of myocardial degeneration. It is opined by theorists that because of RM and consequent secondary relaxation of cardiac muscle, it is not possible to tell whether heart stopped during systole or diastole.<sup>10</sup>

### **AIMS AND OBJECTIVES**

The aims of the study to know the factors like nourishment, temperature and humidity affecting the pattern rigor mortis in hospital deaths.

The determination of time since death is an important factor into the inquiry of death of an individual. The rigor mortis is one such parameter that can help the medical fraternity to deduce the time since death as well as the position of the body at the time of death. Amritsar city of Punjab is known to experience extreme weather, be it summers where the temperature shoots between 40 to 45 degree Celsius or winters when the temperature dips down to 1 to 5 degree Celsius. These contrast climatic conditions affect the appearance and thereby the average duration of the rigor mortis. Thus in this study, an attempt has been made to estimate postmortem interval keeping in view the various environmental like temperature and humidity and other parameters that affect the rigor mortis.

### **MATERIAL AND METHOD**

The present prospective study of 100 medicolegal autopsy cases, was conducted on fully identified patients who died in Guru Nanak Dev Hospital Amritsar with effect from November 1, 2019 after taking permission from the institutional ethical committee and the institutional thesis committee. A written informed consent from close relatives of the deceased was taken. The present study includes the detailed biodata of the case i.e. age, gender, disease (if any), gist of patient history was noted from relatives and person accompanying the dead body who identified it as well as from the inquest papers. A good quality digital hygrometer was used to note the temperature and the humidity at the time of autopsy and were recorded prior to assessing the presence or absence of rigor mortis.

After recording the preliminary data along with all the relevant facts regarding the presence of any demographic data, nourishment and environmental conditions namely the temperature and humidity level during the conduction of post mortem examination, the rigor mortis was studied meticulously by flexing/bending the various joints of the body, lifting the eyelids with the help of index finger, by putting the downward pressure on the chin for opening the mouth, by making an attempt to bend the neck and noting the resistance and by putting pressure with two fingers on intercostal muscles, anterior abdominal muscles and muscles of back of trunk and assessing subjectively the resistance offered by the underlying muscles. In fingers and toes, the movement of the joints were noted cautiously with the help of pulp of fingers by exerting a slight amount of pressure. The degree of the rigor mortis in the muscles was noted with respect to the resistance offered by them.

#### **INCLUSION CRITERIA:**

The medicolegal autopsy cases in which the exact time of death was known as per the hospital record.

#### **EXCLUSION CRITERIA:**

Cases which depicted cold stiffening, heat stiffening, burns, railway accidents, drowning, foetal autopsy instantaneous rigor mortis were not included.

## RESULTS

TABLE 1: RELATION OF RIGOR MORTIS WITH NOURISHMENT

Nourishment	Degree	Percentage	No. of cases	Duration
Well	Appearing	1	1	15 hr 49 min
	Fully Dev	4	4	20 hr 7 min
	Disappearing	8	8	27 hr 22 min
	Absent	3	3	47 hr 16 min
	Total	16	16	-
Moderate	Appearing	5	5	12 hr 10 min
	Fully Dev	18	18	17 hr 58 min
	Disappearing	15	15	27 hr 13 min
	Absent	16	16	45 hr 56 min
	Total	54	54	-
Poor	Appearing	2	2	11 hr 20 min
	Fully Dev	4	4	19 hr 57 min
	Disappearing	10	10	32 hr 11 min
	Absent	12	12	49 hr 55 min
	Total	28	28	-
Emaciated	Appearing	-	-	-
	Fully Dev	-	-	-
	Disappearing	-	-	-
	Absent	2	2	52 hr 0 min
	Total	2	2	-
Total	Appearing	8	8	12 hr 25 min
	Fully Dev	26	26	18 hr 37 min
	Disappearing	33	33	28 hr 46 min
	Absent	33	33	47 hr 53 min
	Total	100	100	-

Out of total 100 postmortem cases, majority of cases 54 (54%) were moderately nourished, followed by 28 (28%) poorly nourished, 16 (16%) were well nourished, and rest 2 (2%) cases were emaciated. Out 54 (54%) cases which were moderately nourished, in 5 (5 %) cases the rigor mortis was appearing with average duration of 12 hours 10 minutes. In 18 (18%) cases, the rigor mortis was fully developed with an average duration of 17 hours 58 minutes. In 15 (15%) cases, the rigor mortis was disappearing with average duration of 27 hours 13 minutes. In rest 16 (16%) cases, the rigor mortis was absent with an average duration of 45 hours 56 minutes. Out of 28 (28%) cases which were poorly nourished, in 2 (2%) cases, the rigor mortis was appearing with average duration of 11 hours 20 minutes. In 4 (4%) cases, the rigor mortis was fully developed with an average duration of 19 hours 57 minutes. In 10 (10%) cases, the rigor mortis was disappearing with average duration of 32 hours 11 minutes. In rest 12 (12%) cases, the rigor mortis was absent with an average duration of 49 hours 55 minutes. Out of 16 (16%) well-nourished cases, in 1% cases, the rigor mortis was appearing with duration of 15 hours 49 minutes. In 4 (4%) cases, the rigor mortis was fully developed with an average duration of 20 hours 7 minutes. In 8 (8%) cases, the rigor mortis was disappearing with average duration of 27 hours 22 minutes. In rest 3 (3%) cases, the rigor mortis was absent with an average duration of 47 hours 16 minutes. In 2 (2%) emaciated cases, the rigor was absent at 52 hours after postmortem examination.

**TABLE 2: CORRELATION OF TEMPERATURE WITH DURATION OF RIGOR MORTIS (APRIL TO JUNE)**

Temperature degree Celsius	Degree of rigor mortis	Duration	No. of cases
21-25	Appearing	-	-
	Fully Dev	-	-
	Disappearing	-	-
	Absent	46 hr 43 min	2
	Total	-	-
26-30	Appearing	-	-
	Fully Dev	23 hr 15 min	1
	Disappearing	29 hr 47 min	3
	Absent	46 hr 5 min	3
	Total	-	7
31-35	Appearing	-	-
	Fully Dev	-	-
	Disappearing	-	-
	Absent	47 hr 38 min	5
	Total	-	-
36-40	Appearing	-	-
	Fully Dev	15 hr 20 min	4
	Disappearing	25 hr 53 min	3
	Absent	-	-
	Total	-	7
>40	Appearing	-	-
	Fully Dev	14 hr 52 min	3
	Disappearing	21 hr 3 min	1
	Absent	-	-
	Total	-	4

Total	Appearing	-	-
	Fully Dev	16 hr 9 min	8
	Disappearing	26 hr 52 min	7
	Absent	46 hr 59 min	10
	Total	-	25

In temperature between 21 and 25 degree Celsius, only 2 cases were observed in which rigor mortis was absent at 46 hours and 43 minutes. In temperature between 26 and 30 degree Celsius the rigor mortis was fully developed at 23 hours 15 minutes. The rigor mortis was disappearing at 29 hours and 47 minutes and was absent at 46 hours 5 minutes. In temperature between 31 and 35 degree Celsius the rigor was absent at 47 hours 38 minutes. In temperature between 36 and 40 degree Celsius the rigor was fully developed at 15 hours 20 minutes. The rigor was disappearing at 25 hours and 53 minutes. In temperature more than 40 degree Celsius the rigor was fully developed at 14 hours and 52 minutes. The rigor was disappearing at 21 hours and 3 minutes.

In April to June, 25 (25%) cases were studied. This season showed 8(8%) cases with fully developed rigor mortis at an postmortem interval of 16 hours and 9 minutes. 7 (7%) cases depicted disappearing of rigor, the postmortem interval of which turned out to be 25 hours and 52 minutes. In 10 (10%) cases rigor was absent with postmortem interval of 46 hours and 59 minutes. The maximum temperature during the season went upto 42 degree Celsius and minimum was 23 degree Celsius.

**TABLE 3: CORRELATION OF TEMPERATURE WITH DURATION OF RIGOR MORTIS(JULY TO SEPTEMBER)**

Temperature degree Celsius	Degree of rigor mortis	Duration	No. of cases
31-35	Appearing	11 hr 55 min	3
	Fully Dev	15 hr 31 min	6
	Disappearing	26 hr 11 min	4
	Absent	39 hr 38 min	3
	Total	-	16
36-40	Appearing	10 hr 40 min	1
	Fully Dev	19 hr 13 min	3
	Disappearing	25 hr 49 min	5
	Absent	42 hr 52 min	6
	Total	-	15
Total	Appearing	11 hr 36 min	4
	Fully Dev	16 hr 45 min	9
	Disappearing	25 hr 59 min	9

	Absent	41 hr 47 min	9
	Total	-	31

In temperature between 31 and 35 degree Celsius the rigor mortis was appearing at 11 hours and 55 mins, was fully developed at 15 hours and 31 minutes, disappearing at 26 hours 11 minutes and was absent at 39 hours 38 minutes. In temperature between 36 and 40 degree Celsius the rigor mortis was appearing at 10 hours and 55 minutes, was fully developed at 19 hours and 13 minutes, disappearing at 25 hours 49 minutes and was absent at 42 hours 52 minutes. In the months from July to September, 31 (31%) cases were studied. 4 (4%) cases showed onset of rigor mortis with postmortem interval of 11 hours and 36 minutes. In 9 (9%) cases, the rigor mortis was fully developed and the postmortem interval of which was 16 hours and 45 minutes. In 9 (9%) cases, rigor mortis was disappearing with the postmortem interval of 25 hours and 59 minutes. In rest 9 (9%) cases rigor mortis was absent with the average duration of 41 hours and 47 minutes. In this quarter the maximum temperature was 39 degree Celsius and minimum reading was 32 degree Celsius.

**TABLE 4: CORRELATION OF TEMPERATURE WITH DURATION OF RIGOR MORTIS (OCTOBER TO DECEMBER)**

Temperature degree Celsius	Degree of Rigor mortis	Duration	No. of cases
≤10	Appearing	-	-
	Fully Dev	-	-
	Disappearing	-	-
	Absent	46 hr 20 min	1
	Total	-	1
11-15	Appearing	-	-
	Fully Dev	-	-
	Disappearing	41 hr 42 min	1
	Absent	52 hr 45 min	1
	Total	-	2
16-20	Appearing	13 hr 15 min	2
	Fully Dev	21 hr 38 min	3
	Disappearing	33 hr 14 min	6
	Absent	56 hr 35 min	4
	Total	-	15
21-25	Appearing	-	-
	Fully Dev	-	-
	Disappearing	31 hr 10 min	1
	Absent	-	-
	Total	-	1
26-30	Appearing	-	-
	Fully Dev	25 hr 30 min	2
	Disappearing	32 hr 45 min	1
	Absent	-	-
	Total	-	3
	Appearing	13 hr 13 min	2

31-35	Fully Dev.	-	-
	Disappearing	29 hr 17 min	3
	Absent	-	-
	Total	-	5
Total	Appearing	13 hr 14 min	4
	Fully Dev	23 hr 11 min	5
	Disappearing	32 hr 44 min	12
	Absent	54 hr 14 min	6
	Total	-	27

At temperature less than 10 degree Celsius, the rigor mortis was absent at 46 hours and 20 minutes. In temperature between 11 to 15 degree Celsius, the rigor mortis was disappearing at 41 hours and 42 minutes and was absent at 52 hours and 45 minutes. In temperature between 16 and 20 degree Celsius, the rigor mortis was appearing at 13 hours and 15 minutes, was fully developed at 21 hours and 38 minutes, disappearing at 33 hours and 14 minutes and absent at 56 hours and 35 minutes. In temperature between 21 and 25 degree Celsius rigor mortis was disappearing at 31 hours and 10 minutes. In temperature between 26 and 30 degree Celsius the rigor was fully developed at 25 hours 30 minutes. The rigor was disappearing at 32 hours and 45 minutes. In temperature between 31 and 35 degree Celsius the rigor mortis was appearing at 13 hours and 13 minutes and was disappearing at 29 hours and 17 minutes.

Table 4 shows that from October to December total 27% cases were studied. 4 (4%) cases showed onset of rigor mortis with postmortem interval of 13 hours and 14 minutes. 5 (5%) cases were the ones with fully developed rigor mortis with postmortem interval of 23 hours and 11 minutes. 12 (12%) cases depicted disappearance of rigor mortis, the postmortem interval of which turned out to be 32 hours and 44 minutes. In rest 6 (6%) cases rigor mortis was absent with the postmortem interval of 54 hours and 14 minutes. The maximum temperature during the season went up to 35 degree Celsius and minimum was 8 degree Celsius.

**TABLE 5: CORRELATION OF TEMPERATURE WITH DURATION OF RIGOR MORTIS (JANUARY TO MARCH)**

Temperature degree Celsius	Degree of rigor mortis	Duration	No. of cases
≤10	Appearing	-	-
	Fully Dev	-	-
	Disappearing	29 hr 0 min	1
	Absent	55 hr 30 min	1
	Total	-	2
11-15	Appearing	-	-
	Fully Dev	-	-
	Disappearing	-	-
	Absent	48 hr 38 min	3
	Total	-	3
16-20	Appearing	-	-
	Fully Dev	20 hr 13 min	2
	Disappearing	26 hr 38 min	2
	Absent	54 hr 4 min	3
	Total	-	7
21-25	Appearing	-	-
	Fully Dev	23 hr 58 min	2
	Disappearing	26 hr 15 min	2
	Absent	45 hr 5 min	1



	Total	-	5
Total	Appearing	-	-
	Fully Dev	22 hr 5 min	4
	Disappearing	26 hr 57 min	5
	Absent	51 hr 5 min	8
	Total	-	17

At temperature less than 10 degree Celsius, the rigor mortis was disappearing at 29 hours and absent at 55 hours and 30 minutes. In temperature between 11 to 15 degree Celsius, the rigor mortis was absent at 48 hours and 38 minutes. In temperature between 16 and 20 degree Celsius, the rigor mortis was fully developed at 20 hours and 13 minutes, disappearing at 26 hours and 38 minutes and absent at 54 hours and 4 minutes. In temperature between 21 and 25 degree Celsius rigor mortis was fully developed at 23 hours and 58 minutes, disappearing at 26 hours and 15 minutes and absent at 45 hours and 5 minutes.

Table 5 shows that in the months of January to march, 4 (4%) cases were the ones with fully developed rigor mortis with postmortem interval of 22 hours and 5 minutes. 5 (5%) cases depicted disappearance of rigor mortis, the postmortem interval of which turned out to be 26 hours and 57 minutes. In rest 8 (8%) cases rigor mortis was absent with postmortem interval of 51 hours and 5 minutes. The maximum temperature during the season went up to 8 degree Celsius and minimum was 23 degree Celsius.

**TABLE 6: CORRELATION OF HUMIDITY WITH DURATION OF RIGOR MORTIS(APRIL TO JUNE)**

Humidity (%)	Degree of rigor mortis	No. of cases	Duration
≤30	Appearing	-	-
	Fully Dev	2	17 hr 47 min
	Disappearing	1	21 hr 3 min-
	Absent	-	-
	Total	3	-
31-40	Appearing	-	-
	Fully Dev	5	15 hr 16 min
	Disappearing	3	26 hr 16 min
	Absent	4	41 hr 25 min
	Total	12	-
41-50	Appearing	-	-
	Fully Dev	-	-
	Disappearing	2	28 hr 55 min
	Absent	1	72 hr 43 min
	Total	3	-
51-60	Appearing	-	-
	Fully Dev	-	-
	Disappearing	1	29 hr 30 min
	Absent	5	46 hr 20 min
	Total	6	-
61-70	Appearing	-	-
	Fully Dev	1	23 hr 15 min
	Disappearing	-	-
	Absent	-	-
	Total	1	-
	Appearing	-	-
	Fully Dev	8	16 hr 9 min

Total	Disappearing	7	26 hr 52 min
	Absent	10	46 hr 59 min
	Total	25	-

In humidity equal to or less than 30%, the rigor mortis was fully developed at 17 hours and 47 mins and was disappearing at 21 hours and 3 minutes.

In humidity between 31 and 40 % the rigor mortis was fully developed at 15 hours 16 minutes. The rigor mortis was disappearing at 26 hours and 16 mins and was absent at 41 hours 25 minutes. In humidity between 41 to 50 %, the rigor mortis was disappearing at 28 hours and 55 minutes and was absent at 72 hours 43 minutes. In humidity between 51 to 60%, the rigor mortis was disappearing at 29 hours and 30 mins and absent at 46 hours and 20 minutes. In humidity between 61 and 70%, the rigor mortis was fully developed at 23 hours and 15 minutes.

Table 6 shows that in the months of April to June, 8 (8%) cases were the ones with fully developed rigor mortis with postmortem interval of 16 hours and 9 minutes. 7 (7%) cases depicted disappearing of rigor mortis, with postmortem interval of 26 hours and 52 minutes. The rest 10 (10%) cases showed absence of rigor mortis at a postmortem interval of 46 hours and 59 minutes. The maximum humidity during the season went upto 65% and minimum was 22%.

**TABLE 7: CORRELATION OF HUMIDITY WITH DURATION OF RIGOR MORTIS (JULY TO SEPTEMBER)**

Humidity (%)	Degree of rigor mortis	No. of cases	Duration
51-60	Appearing	-	-
	Fully Dev	1	19 hr 40 min
	Disappearing	-	-
	Absent	-	-
	Total	1	-
61-70	Appearing	1	15 hr 50 min
	Fully Dev	5	15 hr 46 min
	Disappearing	2	25 hr 17 min
	Absent	2	39 hr 50 min
	Total	10	-
71-80	Appearing	2	9 hr 58 min
	Fully Dev	1	14 hr 50 min
	Disappearing	6	26 hr 8 min
	Absent	3	41 hr 2 min

	Total	12	-
81-90	Appearing	1	10 hr 40 min
	Fully Dev	2	18 hr 43 min
	Disappearing	1	26 hr 25 min
	Absent	4	43 hr 20 min
	Total	8	-
Total	Appearing	4	11 hr 36 min
	Fully Dev	9	16 hr 45 min
	Disappearing	9	25 hr 59 min
	Absent	9	41 hr 47 min
	Total	31	-

In humidity between 51 to 60%, the rigor mortis was fully developed at 19 hours and 40 minutes. In humidity between 61 and 70%, the rigor mortis was appearing at 15 hours and 50 minutes, was fully developed at 15 hours and 46 minutes, was disappearing at 25 hours and 17 minutes and was absent at 39 hours and 50 minutes. In humidity between 71 and 80%, the rigor mortis was appearing at 9 hours and 58 minutes, was fully developed at 14 hours and 50 minutes, was disappearing at 26 hours and 8 minutes and was absent at 41 hours and 2 minutes. In humidity between 81 and 90%, the rigor mortis was appearing at 10 hours and 40 minutes, was fully developed at 18 hours and 43 minutes, was disappearing at 26 hours and 25 minutes and was absent at 43 hours and 20 minutes.

Table 7 shows that in the months of July to September, 4 (4%) cases with appearing rigor mortis with postmortem interval of 11 hours and 36 minutes. 9 (9%) cases were the ones with fully developed rigor mortis with postmortem interval of 16 hours and 45 minutes. 9 (9%) cases depicted disappearing of rigor mortis, the postmortem interval of which turned out to be 25 hours and 59 minutes. Rest 9 (9%) cases showed absence of rigor mortis at an average duration of 41 hours and 47 minutes. The maximum humidity during the season went upto 82 % and minimum was 60 %.

**TABLE 8: CORRELATION OF HUMIDITY WITH DURATION OF RIGOR MORTIS(OCTOBER TO DECEMBER)**

Humidity (%)	Degree of rigor mortis	No. of cases	Duration
61-70	Appearing	-	-
	Fully Dev	2	19 hr 35 min
	Absent	-	-
	Disappearing	-	-
	Total	2	-
71-80	Appearing	1	11 hr 0 min
	Fully Dev	2	26 hr 2 min
	Disappearing	4	35 hr 58 min
	Absent	3	60 hr 22 min
	Total	10	-
81-90	Appearing	3	13 hr 58 min
	Fully Dev	1	24 hr 40 min
	Disappearing	7	31 hr 37 min
	Absent	2	49 hr 0 min
	Total	13	-
>90	Appearing	-	-
	Fully Dev	-	-
	Disappearing	1	27 hr 40 min
	Absent	1	46 hr 20 min
	Total	2	-
Total	Appearing	4	13 hr 14 min
	Fully Dev	5	23 hr 11 min
	Disappearing	12	32 hr 44 min
	Absent	6	54 hr 14 min
	Total	27	-

In humidity between 61 and 70 % the rigor mortis was fully developed at 19 hours and 35 minutes. In humidity between 71 and 80 % the rigor mortis was appearing at 11 hours, was fully developed at 26 hours and 2 minutes, was disappearing at 35 hours and 58 minutes and was absent at 60 hours and 22 minutes.

In humidity between 81 and 90 %, the rigor mortis was appearing at 13 hours and 58 minutes, was fully developed at 24 hours and 40 minutes, was disappearing at 31 hours and 37 minutes and was absent at 49 hours. In humidity more than 90 %, the rigor mortis, was disappearing at 27 hours and 40 minutes and was absent at 46 hours and 20 minutes.

Table 8 shows that in the months of October to December, 4 (4%) cases with appearing of rigor mortis with postmortem interval of 13 hours and 14 minutes. 5 (5%) cases were the ones with fully developed postmortem interval of 23 hours and 11 minutes. Rest 12 (12 %) cases depicted disappearing of rigor mortis, postmortem interval of which turned out to be 32 hours and 44 minutes. Rest of 6 (6%) cases showed absence of rigor mortis at postmortem interval of 54 hours 14 minutes. The maximum humidity during the season went upto 95% and minimum was 68%.

**TABLE 9: CORRELATION OF HUMIDITY WITH DURATION OF RIGOR MORTIS(JANUARY TO MARCH)**

Humidity (%)	Degree of rigor mortis	No. of cases	Duration
61-70	Appearing	-	-
	Fully Dev	2	21 hr 2 min
	Disappearing	2	26 hr 14 min
	Absent	1	45 hr 5 min
	Total	5	-
71-80	Appearing	-	-
	Fully Dev	2	23 hr 8 min
	Disappearing	3	27 hr 25 min
	Absent	3	54 hr 4 min
	Total	8	-
81-90	Appearing	-	-
	Fully Dev	-	-
	Disappearing	-	-
	Absent	3	53 hr 49 min
	Total	3	-
	Appearing	-	-
	Fully Dev	-	-

>90	Disappearing	-	-
	Absent	1	40 hr 0 min
	Total	1	-
Total	Appearing	-	-
	Fully Dev	4	22 hr 5 min
	Disappearing	5	26 hr 57 min
	Absent	8	51 hr 5 min
	Total	17	-

In humidity between 61 and 70%, the rigor mortis was fully developed at 21 hours and 2 minutes, was disappearing at 26 hours and 14 minutes and was absent at 45 hours and 5 minutes. In humidity between 71 and 80%, the rigor mortis was fully developed at 23 hours and 8 minutes, was disappearing at 27 hours and 25 minutes and was absent at 54 hours and 4 minutes. In humidity between 81 and 90% the rigor mortis was absent at 53 hours and 49 minutes. In humidity more than 90 %, the rigor mortis was absent at 40 hours.

In the present study, it is observed that in the months of January to March, 4(4%) cases were the ones with fully developed rigor mortis with postmortem interval of 22 hours and 5 minutes. 5 (5%) cases depicted disappearing of rigor, the postmortem interval of which turned out to be 26 hours and 57 minutes. In the rest 8 (8%) cases, the rigor mortis was absent with an average duration of 51 hours 5 minutes. The maximum humidity during the season went upto 92% and minimum was 68%.

## DISCUSSION

### Nourishment :

The findings of the present study are consistent with the observations of literature of **Reddy** that stated the onset of rigor mortis is slow and the duration long in cases where muscles are healthy and at rest before death [4] and **Glaister and Rentoul**, that stated the stronger muscularity the person is at the time of death, the later is the time of onset and longer the duration. [5] It also correlates with the literature provided by **Di Maio** that stated that rigor mortis may be very weak in emaciated individuals. [6]

The findings correlate with study conducted by **Dalal et al (2006)** [7] and **Oberoi et al (2015)**. [8] The probable reason for similar result was similar demographic area of study i.e Punjab region. The findings of the present study were different from study conducted by **Sugatha et al (2019)** according to which in well-nourished and muscular individuals, the average duration of appearance of rigor mortis was 6 hours 16 minutes and it lasted for 15 hours 45 minutes. The probable difference in the observation is due to the different demographic area of study which is a major factor in contribution to nourishment of an individual. [9]

### Humidity :

The observations of the present study are in consonance with the available literature of forensic medicine of **Reddy [4]**, **Glaister and Rentoul [5]**, **Spitz (1993) [10]**, **Mukherjee (1994) [11]**, **Mant (2000) [12]** and **Mathiharan and Patnayak (2005) [13]** which concludes that rigor mortis persists longer in cold wet air than in fresh dry air and is prolonged by dry cold air and cold water.

The present study correlates with the study of **Sugatha et al (2019)** that states that the important aid in the study of rigor mortis was found in relation to seasons. In this study, it was clearly observed that the onset of rigor was early in summer and delayed in winter with average being in the monsoon season. [9] These findings correlate with those of study conducted by **Dalal et al (2006)** where in the months of April to June, fully developed rigor mortis lasted from 11 hours 25 minutes to 28 hours 25 minutes while in the quarter of July to September; complete rigor mortis lasted from 17 hours 15 minutes to 34 hours 20 minutes. Relative humidity levels in these months varied from 95% to 31%. In the months of October to December, fully developed rigor mortis lasted from 16 hours 25 minutes to 61 hours 5 minutes while from January to March it lasted from 19 hours 5 minutes to 50 hours 15 minutes. The relative humidity during these months varied from 97% to 65%. The similarity of the result is probably the same geographical area of study which decides the atmospheric factors. [7]

### Temperature :

The onset of rigor mortis is slow and duration longer in cold weather. Rigor mortis persists longer in cold wet air than in fresh dry air. It is prolonged by dry cold air and cold water. The onset is rapid due to heat, because of the increased breakdown of ATP, but the duration is short. If the body is in an extremely hot environment and decomposition begins, rigor mortis may disappear in 12 hours after death. It may persist for 3 to 4 days in refrigerated conditions. The present study correlates with the study of **Spitz (1993)** that rigor becomes apparent early in the temperate climate under average conditions and also shows seasonal variation. [10]



Aitchison and Robertson quoted that in warm climates the onset of rigor is rapid and so is the disappearance. [14] Mukherjee stated that the onset of rigor will be rapid and duration short in cases of bodies exposed to warm and moist climatic conditions. [11] **Gordon, Shapiro and Burson** observed that when the environmental temperature is high, the onset of rigor mortis is accelerated and the duration is short. [15] **Di Maio** explained that environmental factors that increase the body temperature would hasten the development of rigor mortis. [6]

The present study differs from the observations of the study conducted by **Dalal et al (2006)**. In the months of April to June, fully developed rigor mortis lasted for an average of 20 hours 30 minutes, while in the quarter of July to September, complete rigor mortis lasted for an average of 25 hours and 47 minutes. In the months of October to December, fully developed rigor mortis lasted for an average of 38 hours and 30 minutes while from January to March it lasted for an average of 34 hours and 40 minutes. Though this study was conducted in same geographical area but over the years there is change in climatic conditions which could have resulted in difference of the observations of the cases studied. [7]. This is different from findings of **Chintalwar et al (2016)** where the average postmortem interval at which we get absent rigor mortis is 21.47 hours in the summer. [16]

The findings of the present study differs from those of **Sivanandam et al (2019)** where the average temperature was higher as compared to the temperature recorded in the present study and rigor mortis appeared early. The probable reason for the difference is due to the difference in the climatic conditions of different geographical area as the study was conducted in hot dry climatic conditions. [17]

## CONCLUSION

In this present study, it can be concluded that the rigor mortis is a definite sign of death and a vital tool in calculating time since death. Environmental factors like temperature and humidity plays an important role in affecting the rigor mortis. Nourishment and age also contribute to the rigor mortis. It is to be noted that the usually taught standard rule of 12 does not always hold true in each case as process of rigor mortis influenced by many variables especially temperature and humidity. The results of this easy and quick conventional method, though subjective, are not precise and accurate.

CONFLICTS OF INTERESTS: None

AUTHORS CONTRIBUTION:

Dr. Jaspinder Pratap Singh:: data collection applying statistics, rechecking data and validation, and helping in preparing the manuscript

Dr. Neha Chaudhary:: literature search and help in preparing the manuscript

AUTHORS FUNDING: None

## References

1. Murthy VK, Rao PCS. Prospective study of mechanical asphyxial deaths. *International Journal of Contemporary Medical Research* 2018; 5:H1-H4
2. Jarvis H, Marc O. Supravital Reactions in Estimation of the Time Since Death (TSD). In: *Human Body Decomposition*, Academic Press 2016 p. 1- 12
3. Gautam B. Signs of Death. In: *Review of Forensic Medicine & Toxicology*, 5<sup>th</sup> Ed Jaypee Brothers Medical Publishers (P) Ltd 2015 p. 141-44
4. Reddy KSN, Murty OP. *Essentials of Forensic Medicine and Toxicology*. 33rd Ed. New Delhi: Jaypee; 2014. (33) p. 162-63.
5. Glaister J and Rentoul E. *Medical Jurisprudence and Toxicology*. 12th ed. Edinburgh and London: E and S Livingstone Ltd. 1966.(12) p. 114.
6. Di Maio VJ, Di Maio D. Time of Death. In: *Forensic pathology*, 2<sup>nd</sup> Ed CRC Press 2001;(2) p 46-62
7. Dalal JS, Tejpal HR, Chanana A, Kaur N. Medicolegal Study of Rigor Mortis to Estimate Postmortem Interval JIAFM. 2006;28(2):49-51.
8. Oberoi SS, Singh P, Aggarwal AD, Walia DS, Bhullar DS, Aggarwal KK. Factors affecting estimation of time since death by rigor mortis. *Journal of Punjab Academy of Forensic Medicine & Toxicology*. 2015;15(2):81-85.
9. Sugatha M, Ramana V. Assessment of time since death using forensic autopsies based on the

- presence of rigor mortis– a cross-sectional study. International Journal of Contemporary Medical Research 2019;6(4):D11- D14.
10. Spitz WU, editor. Spitz and Fisher's medicolegal Investigation of Death. 3rd ed. Illinois (USA):Charles C Thomas Publisher; 1993;3:26-8.
  11. Mukherjee JB. Forensic Medicine and Toxicology. 2nd Ed. 1994;2:223-32.
  12. Mant KA. Taylor's Principles and Practice of Medical Jurisprudence. 13<sup>th</sup> ed. 1986;13:140-45.
  13. Mathiharan K, Patnaik AK. Postmortem changes and time since death. In: Modi's Medical Jurisprudence and Toxicology. 23<sup>rd</sup> ed. New Delhi: LexisNexis Butterworths India; 2005 p. 423-62
  14. Aitchison WG, Robertson. Manual of Medical Jurisprudence & Toxicology. 5th ed. 1925 (5), p. 65-69.
  15. Gordon I, Shapiro HA. Textbook of forensic Medicine. 1st ed. 1975. p. 10- 18.
  16. Chintalwar RS, Patond S, Ninave S. Estimation of Time Since Death from Postmortem Lividity. Indian Journal of Forensic Medicine & Toxicology. 2019;13(4):1-7.
  17. Sivanandam M, Shankar GP. Assessment of onset and progress in the high ambient environmental temperature influenced on rigor mortis in Tirunelveli district. Int J Forensic Med. 2019;10(1):01-05.